SCIENTIFIC AMERICAN SUPPLEMENT, No. 1850

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1910, by Munn & Co., Inc.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXXI., No. 1850.

NEW YORK, JUNE 17, 1911.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

Excavations at Susa

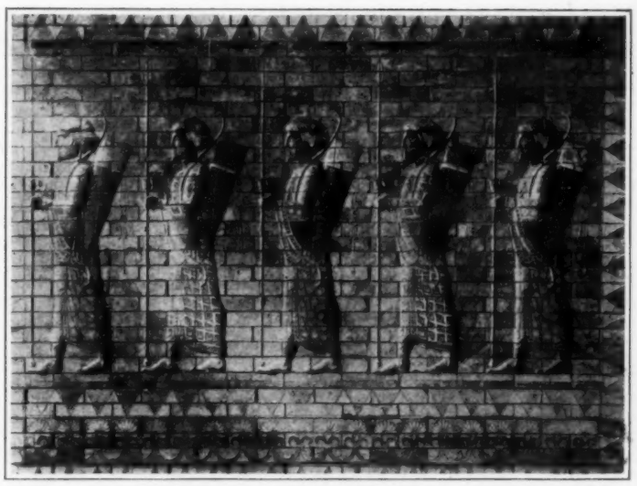
By Our Paris Correspondent.

THE remains at Susa interest us in more ways than one, for this city was not only one of the leading centers of the Persian Empire, and for a long period the residence of royalty, but also figured as the scene of the biblical story of Esther and Ahasuerus. The site is now covered by immense mounds which rise above the surrounding desert plain. We should no doubt know a great deal more about it, but for its isolation in the far interior, which renders it difficult of access, and makes the transportation of finds extremely difficult. M. Dieulafoy, an eminent Paris archæologist, was the first to discover any important remains at Susa, and some of the results of his work have been selected as the subject of this article.

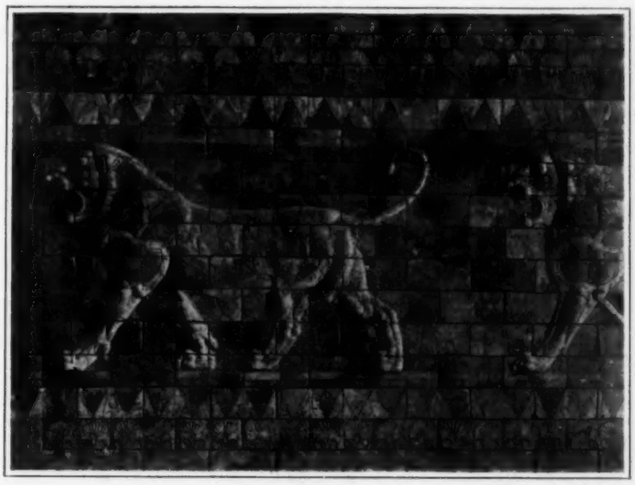
According to M. Dieulafoy's description, the city must have presented an imposing appearance as viewed on approaching it from the surrounding country, with its royal acropolis, a great fortified place situated on a height above the rest of the city. Here the walls and towers built of sun-dried brick rose to thirty times a man's height. After passing through the city and the commercial quarters we follow a wide avenue which leads up to the acropolis. The fortifications were surrounded by a moat which took its water from the neighboring Choaspes stream. No less than sixty feet thickness was given to the brick walls, so as to furnish the strength to withstand the shocks of battering rams. Spaced around the walls were watch towers and postern gates, and a main gate at the front gave access to the interior. This gate was flanked by two projecting towers as we see them in fortifications of the Middle Ages, and there were also covered porticos here which served as the center of life outside the palace. We may imagine Mordecai sitting under the portico, according to the Bible story, waiting to communicate with Esther, who occupied the women's apartments in the King's palace within the walls.

CAPITAL OF COLUMN IN THE THRONE ROOM AT SUSA

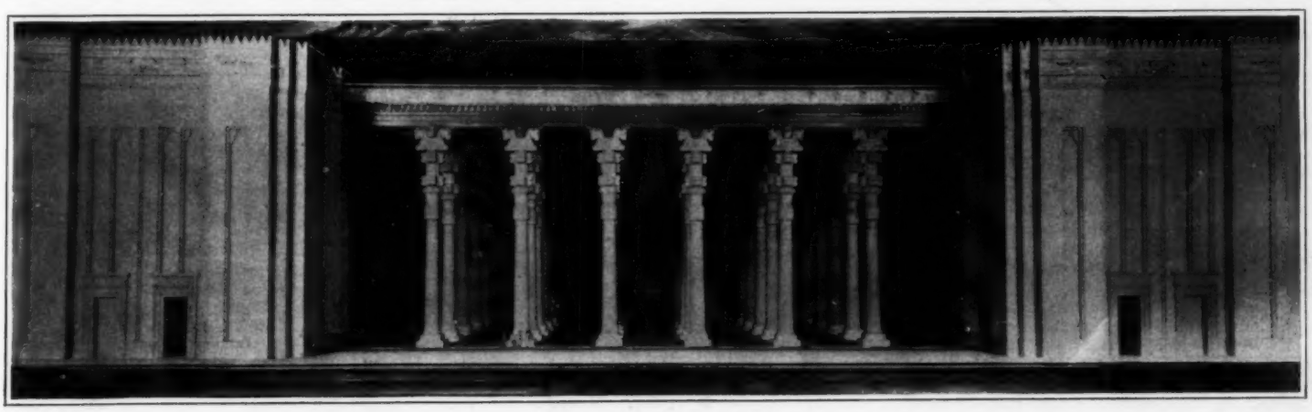
After passing the great gate we come to a high tower resembling the donjon of our early fortresses. This formed one corner of the outer work, being, however, separated from the main walls by a space, so as to be better protected. This part, however, remains to be excavated. No doubt it served as a last refuge for the soldiers and inhabitants of the royal city, where they could flee for protection in time of danger. Farther on is a large central space which was originally the great central square or parade ground. Around the square were various structures. On one side is the Citadel, occupying another point on the fortification walls, and dominating with its great towers the rest of the work. It was shaped somewhat like the Assyrian forts with which we are familiar. On the other side of the square is the King's private palace, containing the women's apartments, where Esther lived. We do not know as yet whether any parts of the ancient buildings remain, as there have been no excavations made here up to the present time. Opposite is the great throne room,



A FRIEZE FORMED OF FIGURES REPRESENTING ARCHERS, SUSA



FRIEZE OF LIONS AT SUSA



MODEL OF THE "THRONE ROOM"

EXCAVATIONS AT SUSA

which is shown in our illustration, and which deserves special mention, as it was on this spot that M. Dieulafoy carried out most of his work. The structure lies on an elevated space, and covers much ground. A great double staircase led up to it from the square, with balustrades of enameled brick in handsome designs and colors, and the steps were wide enough to accommodate thirty men abreast, and even horsemen could mount them. At the bottom and also at the upper level were high gates or pylons, adorned with a handsome decorative border of lions in enameled brick. Beyond the gate were gardens very tastefully laid out with trees and flowering plants, and we may suppose that a gay array of brilliantly colored tents, set up with cedarwood poles and fastened with silver rings, were scattered over the landscape.

Especially striking owing to its vast proportion is the *apadana* or throne room, which was used by the Persian kings for special occasions. Here the King held his court and received tributaries or ambassadors from surrounding nations. Enough of the remains of this large building were found to give a very good idea of what it looked like in ancient times, and the model shown in our illustration has been prepared in accordance. The building was almost an open structure, and had a central hall surrounded on three sides by porticos upheld by columns. The entire building covered about half an acre. Six ranges of great columns made from the gray stone of a neighboring quarry upheld the roof of the principal part. The columns were no less than sixty feet in height. One of the capitals of the columns was found almost entire, and is shown in our engraving. It was brought to Paris after much labor, as this great mass of stone was very difficult to transport.

The roof beams are supported on a double figure of gray stone representing kneeling bulls. In the original state the horns and ears were no doubt of gold, but they are now restored in copper. The general treatment of the capital is a combination of Egyptian, Greek and Chaldean styles. Near the roof, all around the building, ran a wide frieze representing a long file of lions, inclosed in a decorative border. A part of this frieze was found, sufficient to piece together a few entire panels in an excellent state of preservation. This exceedingly handsome frieze is shown in one of our illustrations. The lions are represented between borders having a lotus decoration, and are remarkably executed in molded brick, colored alternately with different enamels. The colors in the frieze are white, yellow, blue and green, and the background is a soft turquoise blue, so that the whole design gives a very rich effect. As enamel colors hardly change at all with time, we have the frieze in almost the same state as in the ancient period. The front of the throne room has no doors, and it is likely that curtains were hung down in the spaces between the columns so as to shield the inside from the sun, and these could be raised or lowered to give shade when it was needed.

Oriental magnificence was not spared on the inside of the throne room, to judge by the remains which were found on the spot. It was lined with a red stucco, but no doubt the walls were nearly or quite covered with tapestries of the most gorgeous colors. In the niches of the walls were gold and silver vases and like ornaments. Some of these were gifts made to the King by tributary nations, such as the gold plane tree presented to Darius by the satrap of Phrygia.

Cedar of Lebanon formed the roof beams, and this was incrusted with gold and mother of pearl, leaving the wood also visible, as at that time cedar was counted as a precious wood, and was no doubt treated by waxing or polishing it in some way. On the floor were brightly colored carpets representing subjects with men and animals, hunting scenes and the like. The King sat under a dais upon a carved silver throne and held a scepter in his hand. Amid all this magnificence sat the descendant of Darius and Xerxes who ruled at that time over all the neighboring world, including Persia, Chaldea, Asia Minor and Egypt. The King was recognized as the elect of the divinity Ormazd, and the remains of an inscription bearing a dedication to this divinity were found on the spot.

The present building was erected by Artaxerxes Memnon, and lies on the site of a more ancient building of the time of Darius I. A part of the decoration of the older structure was also found, namely, a very handsome frieze of enameled brick representing the soldiers of the King's bodyguard. These figures of the Persian soldiers or archers are remarkably well executed, and the colors are most pleasing. The archers hold a short javelin before them, and on their shoulder carry bow and quiver. According to the ancient writers, the Persian kings had, in addition to their foot guard, a special bodyguard of 10,000 men called the "immortals." Of these, 9,000 had iron-headed javelins with silver pomegranates at the end, a description which corresponds strikingly with the figures shown on the frieze. The remaining 1,000 men were a special select corps, and carried spears with gold pomegranates.

As regards the story of Esther and Ahasuerus (Darius I.), it is to be remembered that the events in question took place before the present *apadana* was built. However, the archers' frieze belongs to that period, as it was part of the earlier building. Perhaps the remains of other buildings of the period mentioned in the Bible still exist in the parts which remain to be explored.

Radiant Energy and Matter—II*

Sir J. J. Thomson's Royal Institution Lectures

Continued from Supplement No. 1849, page 364

IN opening his second lecture, Sir J. J. Thomson said that he has on the last occasion discussed some views which had been put forward to explain whence the sun derived the enormous energy it radiated, which, according to various estimates, ranged from 10,000 to 15,000 horse-power per square foot of its surface.

The radiation from the sun, Prof. Thomson proceeded, traveled away through space, a small portion of it falling on the planets. Of the energy they were thus continuously acquiring the planets saved but a small amount. The earth, for instance, did not retain any appreciable quantity, giving it back to space again, also in the form of radiant energy.

It was possible to form an estimate of the temperature a body would acquire under the influence of the sun's radiation, if it lost just as much energy as it received. Prof. Poynting had thus calculated the temperature of the different planets on this hypothesis. In this calculation there were some uncertain factors, particularly as to the quantity of radiation reflected. In the case of the earth this was an appreciable amount. Making, however, the most probable allowances and estimates, it appeared that Mercury would have a temperature of 467 deg. absolute, or 194 deg. C., Venus, one of 368 deg. absolute, or 95 deg. C., while the corresponding figure for the earth was 290 deg. absolute, or 17 deg. C. In this case the calculation could be checked, and the figure given represented very well the average temperature of the earth. Calculated in the same way, the temperature of Mars came out as — 38 deg. C., or far below the freezing point of water. This appeared unfortunate for the canals, but he believed that Mr. Lowell had ways of meeting the difficulty. The temperature of Neptune, calculated in the same manner, was — 215 deg. C., so that this planet presented exceptionally favorable conditions for the conduct of low-temperature research. In this connection the question also arose as to what would be the temperature of a body exposed to starlight only. Astronomers estimated starlight as equivalent to $\frac{1}{20000000}$ of bright sunlight; and, taking this as the basis of the calculation, it appeared that a body exposed solely to the radiation of the stars would acquire a temperature of 10 degrees absolute.

The main portion of his last lecture, he proceeded, had been devoted to showing the connection between the total amount of radiation given out by a black body and the absolute temperature of that body. All the most recent experiments showed that the amount of energy radiated per square centimeter of surface could be represented by the $5.32 \times 10^{-5} \theta^4$ ergs per second. The erg was a convenient unit for purposes of calculation, but was too small for engineering purposes, one erg being about the amount of energy exerted by a common house fly when it crawled up a window pane a height equal to the breadth of one's finger nail.

The expression above given for the radiation from a black body had been applied in a most ingenious way to the measurement of the temperature of furnace fires, and the like, by means of the Féry pyrometer. In this instrument the light from a furnace was focused by means of a mirror onto a thermopile, which thus received a fraction of the total radiation emitted by the body to which it was directed. It was thus necessary merely, as it were, to look at a furnace with the instrument in order to determine its temperature. As he had stated last time, the fourth-power law had originated in some calculations made by Stefan on some experiments made long ago by Tyndall. It had since been shown that this law was the only possible one in accord with thermodynamics.

This conclusion resulted from a consideration of the pressure due to light. In fact, all radiant energy exerted a pressure on a body which absorbed it. This was almost self-evident when light was thought to be a stream of small particles moving with great velocity. If such particles were absorbed by a body, the latter would be pushed forward, the effect being equivalent to a pressure exerted on the body. When the undulatory theory was introduced, however, it was not clear that there would be any similar pressure if light were a wave motion. In fact, this very point had been taken as a crucial distinction between the old and the undulatory theory. The experiment had been tried by Bennett, who allowed light to fall on a delicately suspended disk, and fortunately, perhaps, for theory, had failed to detect any motion. We now knew that had more delicate methods been adopted, the result would have been different; but had this been the case, the experiment would have been almost a death blow to the undulatory theory. It was not till long afterward that it was shown that on the electro-magnetic theory also radiation must exert a pressure on bodies which absorb it.

It was somewhat remarkable that many of the more recently discovered properties of light were in many respects more easily explained on the old corpuscular theory than by means of its successor, and this question as to the momentum of radiation was an instance in point. Maxwell, however, showed that if light were an electro-magnetic disturbance, a beam of it must possess a certain amount of momentum in the direction of its motion, and was accordingly, in this regard, mechanically equivalent to a stream of particles. Hence, when light was absorbed, all its momentum was communicated to the absorbing body as a pressure. This was not likely, however, to lead to any practical inconvenience. On an average-sized man standing in full sunlight the total resultant pressure only amounted to about ½ milligramme. It was indeed a great triumph that these excessively small effects should have been demonstrated, and measured within a few per cent, with laboratory apparatus, in which the total force acting was but $\frac{1}{5000}$ part of a milligramme.

The effect in question, Prof. Thomson proceeded, must be distinguished from that which caused rotation in Crookes' radiometer. When this was first invented the effect was believed to be due to light pressure, and the instrument was sometimes referred to as a mill driven by light. Further work showed that the forces in operation had a different origin, the motion observed being due to the communication of momentum between the hot plates of the rotating part and the colder walls of the containing vessel. It was, the lecturer proceeded, easy to distinguish between a purely domestic affair of this kind and an effect due to an external cause, such as was the pressure due to light. In fact, any effect due to the action of the glass in pushing particles of air against the vanes could not produce rotation of the apparatus as a whole, a self-contained system being incapable of acquiring momentum. It would be as impossible for the radiometer effect to produce rotation of the instrument as a whole, as for the passengers facing the engine in a train to assist in propelling the latter by hitting those on the opposite seats. Action was balanced by reaction; and, if the vanes moved round in one direction, then the casing, if freely suspended, would turn in the other. To show that this was indeed the case, the lecturer suspended a radiometer complete from a fine wire. When exposed to a strong light the vanes rotated in one direction, while the bulb of the instrument moved round slowly in the other.

This radiometer effect, Sir Joseph continued, was one of the difficulties which had to be got rid of in experiments on the pressure of light. Its effect was very large as compared with the latter. Another difficulty arose from convection currents. If the air in the vessel used got warmed, currents were set up, which acted with forces almost infinite in comparison with the light pressure to be measured. These could be got rid of by placing the apparatus in a vacuum, but this made the radiometer effects worse. The problem was thus a difficult one. The radiometer effects could, however, be avoided by taking advantage of the fact that they were purely a domestic affair, and that if the vane were rigidly con-

* Report of Sir J. J. Thomson's lecture, reproduced from *Engineering*.

nected to its containing vessel they would cancel out.

This was done, the lecturer continued, in the apparatus devised by Prof. Poynting. In this the vanes to be subjected to the pressure of light were rigidly connected to their mica case, the whole being suspended in a vacuous vessel from a quartz fiber. The mica absorbed very little of the radiation, and its temperature therefore remained much the same as that of the outer vessel. On exposure to light the pressure on the vanes caused the whole of the mica vessel to deflect, the amount being measured by a spot of light reflected from a mirror.

The pressure due to light was, the speaker continued, first detected by the Russian physicist Lebedeff, and a little later Nicolls and Hull succeeded in getting a very satisfactory agreement with the predictions of theory. On the theory that light consisted of a stream of particles, there was also a pressure produced, but different in amount, so that the experiments made served to discriminate between this theory and the electro-magnetic theory. With the former the pressure produced would be just twice as much as with the latter. Hence, if we could trust our experimental results within a margin of 50 per cent, it was possible to determine which theory best satisfied the experiments. Messrs. Hull and Nicolls found their results in close agreement with the requirements of the electro-magnetic theory, the difference not amounting to 10 per cent.

Since light exerted a pressure it was possible to conceive of an engine operated by this pressure. The amount of power produced might not be at all formidable and would make no show in the industrial world; but all such engines, whether large or small, were subject to the same laws, since there was not in thermodynamics one law for the rich and another for the poor. Suppose then a cylinder fitted with a piston and filled with light instead of with gas. This light would exert a pressure on the piston. Calling the energy of the light per unit volume E, then the pressure per square centimeter on the piston was numerically equal to 1/3 E by the electro-magnetic theory, while in the case of a gas filling the cylinder it would be 2/3 E.

Suppose now the piston was allowed to rise so as to alter the volume below it by the amount v^1. Then the work done would be $p\,v^1$. At the same time, however, in order to fill up the space left behind and thus keep the temperature constant, energy equal to $E\,v_1$ must also be supplied.

Hence the total supply of energy must be

$$p\,v^1 + E\,v^1, \text{ or since } p = 1/3\ E$$

we had

$$p\,v^1 + E\,v^1 = 4\,p\,v^1.$$

But it was shown in thermodynamics that in that case we must have*

$$4\ p\ v^1 = \theta - \frac{d\,p}{d\,\theta}\ v^1$$

$$\text{or } 4\ p = \theta - \frac{d\,p}{d\,\theta}$$

where θ denoted the absolute temperature.

Integrating this gives $p = 1/3\ E = c\ T^4$, which was the fourth-power law.

The existence of this pressure due to radiation had, Sir Joseph continued, been put to a great many uses as an explanation of phenomena. Thus it had been supposed sufficient to account for the existence of comets' tails, and Arrhenius had suggested that it served to regenerate the available energy of the universe, now being continually dissipated in various ways. For his own part he thought a little too much had been made of the fact that light produced a pressure, and that the application of a little cold arithmetic would show that the hypotheses framed were hardly warranted by the facts.

As for comets's tails, it was, of course, true that light from the sun would exert a pressure on small opaque bodies, which, if sufficiently minute, might be repelled, in spite of gravitation. Gravitational attraction was proportional to the volume of a body, while the light pressure was proportional to the surface. Hence, if the bodies were made smaller and smaller, we must at last come to a size when the repulsion due to light would exceed gravitational attraction. For this repulsion to come into play, however, the light must be absorbed. If the particles were transparent, there would be no repulsion. If a comet's tail consisted of dust, then, no doubt, the light pressure would sweep out this dust from the doorsteps of the sun. If, however, the tail were gaseous, then to get the gravitation balanced by the light pressure this light must be absorbed. It could be shown that the light pressure due to the sun was one ten-thousandth of a milligramme per square centimeter, and hence if 1 square centimeter had a mass of one-tenth of a milligramme behind it, the light pressure would just balance the attraction. Hence 1/10 milligramme must suffice to absorb all the light incident on 1 square centimeter. No gas was, however, known which was capable of doing this. Hence, if the comet's tail were gaseous, one could hardly conceive that its repulsion was due to the pressure of the sunlight.

This pressure of light formed an excellent illustration of Le Sage's theory of gravitation, which assumed that all masses in the universe were being bombarded by particles coming from all directions. Each mass would, therefore, shield its neighbor from some part of the bombardment it would otherwise receive, and hence the two would be impelled toward each other. The same kind of thing happened in the case of radiation pressure. Two cold bodies placed within a warm inclosure would each shield the other from a certain pressure it would otherwise receive from the radiation from the walls, and the two would tend to move as if attracted to each other. If, on the other hand, the bodies were hotter than the inclosure, they would repel each other. Prof. Poynting had thus shown that two globes, each of 20 centimeters radius, and at the temperature of boiling water, would, if radiating freely into cold space, repel each other with a force exactly equal to their gravitational attraction. It might be asked, he continued, whether this effect was not a serious thing for experiments on gravitational attraction, and undoubtedly it would be so if the walls of the inclosure in which such experiments were made were much cooler than the apparatus experimented with. In the actual conditions of the experiment, however, the radiation pressure canceled out.

(To be continued.)

* Engineers will recognize the equation better in the form

$$v\,d\,p = L\frac{d\theta}{\theta}$$

the well-known relation between the specific volume of steam and its latent heat. This gives $L = \theta\frac{d\,p}{d\,\theta}\cdot v$, and L being the total energy added at the temperature T is the equivalent of $4\,p\,v^1$ above.

Fixing the Day of the Week of Previous Dates

Some Curious Rules and Their Application

By Robert Grimshaw

In combating the erroneous idea that Friday is an unlucky day, and in advancing the fact that for America it has been a particularly lucky one—if there be any such thing as luck—any one who will look up American history from the date of Columbus's sailing to the important battles in Mexico and elsewhere will be convinced that Friday and thirteen are for us lucky. I incidentally stumbled upon the method of determining the day of the week on which a given date fell—a system of calculation which is employed by the lightning calculator Leo Erichsen on the German variety stage, and which, as it is probably new to most of the readers of this periodical, I present in detail.

In the ordinary year of 365 days there are 52 weeks and one day over, which latter extra day renders more difficult the determining of the day of the week in times gone by—a difficulty which is increased by the presence of the extra day of the leap year, and still further by the absence of this extra day on certain even hundreds of years. From this arrangement that the year ends on the same day of the week as that on which it begins springs the "catch" which is usually successfully employed as a bet—that "this year Christmas and New Year's Day do not fall on the same day of the week." Naturally; for the "New Year's Day" of which the victim thinks is not in the same year as the Christmas in question, but in the next.

Now if the year 1 of our Lord began on a Saturday, the year A. D. 2 began on a Sunday, and A. D. 3 on a Monday. After seven years of 365 days each, the same order occurs again. So we start with the fact that the year 1 began with a Saturday. The same is true of the year B. C. 10001, which astronomers call minus 10000.

In dividing by seven the number of the years of 365 days each since the year 1 of that period, we have as remainders for Saturday 0, Sunday 1, Monday 2, etc. But the occurrence of leap year complicates the matter. The number of days which have been "inserted" by the extra day of February is ascertained by dividing the number of the year by 4. This is good all the way through for the so-called Julian calendar, which is still in use and force in Russia, Bulgaria and Servia. But according to the Gregorian calendar, by which we now reckon, and which was introduced by the papal bull of 1582, October 5th, *Inter gravissimas*, there were cut out from the date mentioned until 1700 ten days, for the eighteenth century 11 days, for the nineteenth 12, and for the twentieth (our own) 13, from the Julian calendar. This is to be considered, after dividing the number of the year by four. Therefore, when we calculate, the day of the week of the year A. D. 1 must be thrown back one day a year more from Saturday of the year 1; further by one day for each leap year; and if the date according to the Gregorian calender is desired, the number of the missing days is to be subtracted from the date according to the Julian calendar. The result of the calculation determines the number of weeks which have elapsed from January 1st up to the date in question. This is the only part of the calculation which requires any act of memory on the part of the "lightning" or other calculator. He must keep in mind that on the "0" day of each month since January 1st there have elapsed in January 1 day, in February 30, March 58, April 89, May 119, June 150, July 180, August 211, September 242, November 303, December 333 days. (With the aid of the ordinary mnemotechnic rules these numbers will not be very difficult to retain in the mind.) It is easy to see that on the 16th day of January 15 days have elapsed since January 1st; on November 7th, 310, etc.

The practical application of the rule is much more easy than it would at first seem, in view of this theoretical discussion. First, 1 is to be subtracted from the number of the year and the remainder divided by 7. The remainder, if any, of this division is called the "first remainder." Then the undiminished whole number of the year is to be divided by 4. From the quotient (which for dates before February 29th is to be lessened by 1) the number of missing days according to the "reformed" or Julian calendar is to be subtracted. This difference is to be divided by 7, and the remainder, if any, called the "second remainder." Finally, the number of days since January 1st is to be divided by 7, and what is over, if any, then called the "third remainder." The three remainders are to be added together and the sum divided by 7; so that at last there is a final remainder which will be one of the numbers 0 to 6 inclusive. If this "final remainder" be 0, the day of the week was Friday; if 1, it was Saturday; and so on.

As an example we take the date 1628, January 28th (this order being chosen for convenience): $1611 - 1 = 1610$; $1610 \div 7 = 230$; first remainder, 0; $1611 \div 4 = 402$. The number of missing days for the seventeenth century is 10; then $392 \div 7 = 56$, with no remainder; so second remainder is 0. On January 28th there were 27 days elapsed since January 1st; the third remainder after dividing 27 by 7 is therefore 6. The sum of the three remainders is 6, which shows that the date in question fell on a Friday.

Suppose we choose as an example 1423, May 30th. $1423 - 1 = 1422$, which after dividing by 7 gives as first remainder 1; $1423 \div 4 = 155$; $155 - 10 = 145$; $145 \div 7 = 20$, leaving as second remainder 5; May 30th (149 days elapsed), $149 \div 7 = 21$; third remainder 2. Sum of the remainders, 8; then final remainder 1, calling for a Sunday.

This method has been known for some time, although not to a very large circle. A novelty is its application to dates before the birth of Christ, as explained by Kretzinger of Berlin. To work this out, it is necessary to call the year by its "astronomical year number," that is, one less than the number which we give it. This number is subtracted from 10,000, and the difference divided by 7 to get the first remainder. The same difference is then divided by 4, and the quotient increased by 1, because minus 10,000 was a leap year. Only in such years it remains up to February 28th unchanged; otherwise the old rule applies. As an example:

—2865 B. C., February 17th.

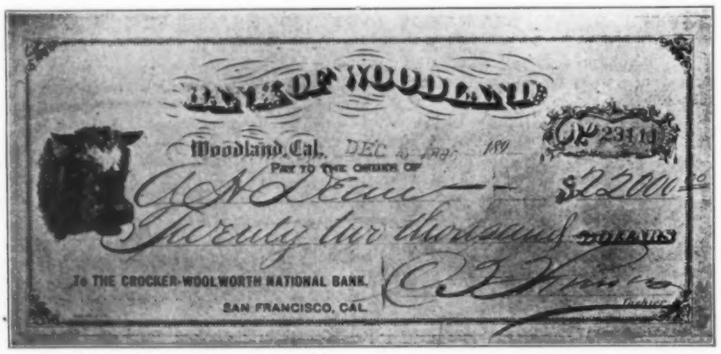
$-2864 + 10{,}000 = 7136$; first remainder, 3; $7136 \div 4 = 1784$ (no addition, because the date lies before February 29th, and the year is not divisible by 4); $1784 \div 7 = 254$; with 6 as second remainder. On February 27th there were 47 days elapsed since January 1st; remainder $47 \div 7 = 5$. Sums of the remainders, $3 + 6 + 5 = 14$; final remainder (after dividing 14 by 7), 0. Therefore, the day of the week would have been Friday.

The Alteration of Checks*

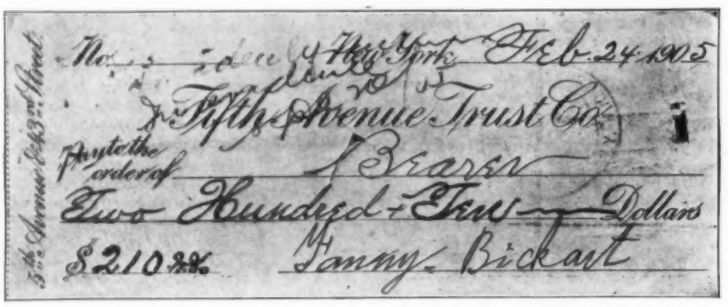
How Alterations are Made in Spite of Safety Tint Paper and Check Punches

By William J. Kinsley

IF all forgers were as skilful, as painstaking and astute as was Charles Becker, of Brooklyn, when in 1896 he raised a draft of the Bank of Woodland, California, on the Crocker-Woolworth Bank of San Francisco, from twelve dollars to twenty-two thousand dollars, the protection of banks against alterations would be almost impossible—particularly so when drafts and checks are cashed in the rather hurried manner almost unavoidable in the rush hours.



A DRAFT, ORIGINALLY FOR TWELVE DOLLARS, RAISED TO TWENTY-TWO THOUSAND DOLLARS



RAISED FROM TEN DOLLARS TO TWO HUNDRED AND TEN DOLLARS

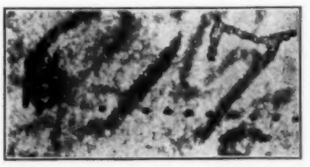
So artistic was Becker's alteration of this twelve-dollar draft that a careful examination under the microscope was necessary for its detection. The draft had been duly protected with a check punch, but restored thereafter by means of water color. The raised amount was then inserted in letters and figures, new perforations to "protect" the twenty-two-thousand dollar draft were made with a hand punch, and the raised draft was complete.

The altered draft was cashed without exciting suspicion and without unusual difficulty, and before its fraudulent nature was discovered Becker had disappeared. It was only after a two-years' chase all over the United States that he was finally located and arrested in Newark, New Jersey. On his first trial the jury disagreed, but at the opening of the second trial Becker pleaded guilty and was sentenced to two years' imprisonment in the California State Prison.

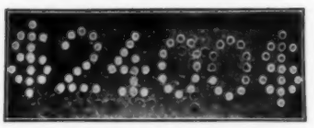
Upon the completion of Becker's sentence he returned to his former home in Brooklyn. I have been informed by one of the officers of a safety paper company that since then Becker applied to them for a position as salesman and demonstrator of the *advantages* of using safety paper for checks and drafts. It is needless to say that he was not engaged.

The Work of an Artist.

Probably the best educated and most famous forger in the United States is Alonzo J. Whiteman, who is now completing an eight-year term in the Auburn, New York, State Prison, for raising a draft drawn by the National Hudson River Bank of Hudson, New York, on the Mechanics National Bank of New York city. The draft was drawn for nine dollars. It was raised to nine thousand dollars.



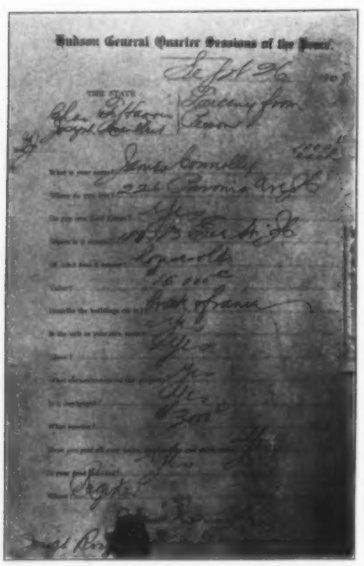
RAISED FROM ELEVEN TO SEVENTEEN*



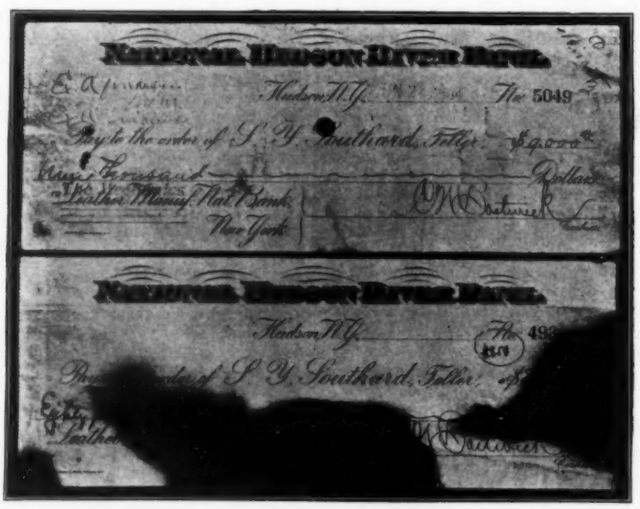
ARTISTIC CHECK PERFORATING. ORIGINAL HOLES FILLED AND NEW AMOUNT PUNCHED*

RAISED FROM FIFTEEN TO TWENTY-THREE*

Preparatory to this transformation Whiteman purchased several small drafts from the National Hudson River Bank. Experiments were then made with different acids to ascertain their effect when erasures were made. On two of the drafts the acids evidently failed to work properly, discoloring the paper. These damaged drafts were first burned sufficiently to efface the incriminating discolorations and were then returned to the bank by Whiteman or his confederates for redemption, with an explanatory note stating that since the drafts were not paid they were returned for correction. The bank officials, suspecting nothing, redeemed the drafts and returned them to the depositor.



BOND WITH ORIGINAL SIGNATURE ERASED AND NEW SIGNATURE INSERTED



THE UPPER DRAFT HAS BEEN RAISED FROM NINE TO NINE THOUSAND DOLLARS. THE LOWER DRAFT WAS DAMAGED IN AN EXPERIMENTAL "RAISING" AND WAS REDEEMED BY THE ISSUING BANK*

paper was chewed into a plastic, pulp-like mass, the old perforations were filled, and these fillings were hardened and ironed. The draft was on a safety tint paper, but this did not prevent the erasure of the amount by means of acid, the surface and tint being

* *The Business World.*

* The illustrations marked (*) are from photographs made by Albert S. Osborn, Examiner and Photographer of Documents, New York.

ing that the papers had been accidently burned by cigar ashes. The drafts had undoubtedly been burned and the bank very obligingly redeemed them both. The illustration on the preceding page shows one of the damaged drafts.

Whiteman's next attempt was evidently successful, since one of the drafts originally for nine dollars, but now raised to nine thousand dollars, was shortly thereafter deposited in the Fidelity Trust Company, of Buffalo, New York—where an account was opened—and a large part checked out before the fraudulent nature of the draft was discovered.

Whiteman fled, but was arrested some six months later in St. Louis. While on his way home for trial he jumped from the window of a Pullman car within a few miles of Buffalo and made his escape. He fled to Mexico, but later returned to his home in Dansville, New York, where he was again arrested. He was convicted in October, 1905, by Assistant District Attorneys Frank A. Abbott and John W. Ryan, of Buffalo, and was sent to prison for a term of years.

I testified at Whiteman's trial. While securing autographs of the attorneys in the court room at the close of the trial, Whiteman came over and said, "I know that you want my name," and put his autograph in my book as though proud to have it there. He seemed to feel no animosity for my part in his conviction.

After Whiteman had been in prison about a year, I met his attorney, and, as a matter of curiosity, asked him what work Whiteman was doing in jail. The attorney replied, "Teaching." I asked "Teaching what?" and the attorney replied, "Business."

Common Methods of Raising Checks.

There are various methods of raising checks. One of the commonest is to take advantage of spaces either before or after the original writing. If space is left to the right of the amount, terminal letters or figures changing the amount are easily added. Thus, a check drawn for seven dollars is, if moderate space has been left to the right, readily raised to seventy. Likewise if there is space at the left of the amount it may easily be raised by the insertion of the proper words and figures. Thus a check for five hundred dollars is by the insertion of forty, fifty, etc., in space at the left, readily raised to forty-five hundred, fifty-five hundred, etc.

A Forgery or an Alteration.

This method has been followed on occasions with much success. In the Bickart check shown in the accompanying engraving the depositor claims the signature is a forgery; while the bank claims that the signature is genuine, but that the amount has been "raised" from ten to two hundred and ten dollars—in the same handwriting. The writer of the body of the checks (who also cashed them) is serving a sentence in Sing Sing Prison for his part in the work.

Wholesale Alterations.

In a recent case, dozens of checks were put in evidence which the depositor claimed had been variously raised from six, seven, eight and nine dollars to larger amounts by adding "teen" to them. The checks, both as to the original amounts and the raised amounts, were all in one handwriting, and it was charged that the bookkeeper made the changes after the depositor's signature had been affixed. This was, of course, a comparatively easy thing to do, but a fraud very difficult of detection.

Other Methods of Altering Checks.

Another method of altering checks, much in vogue, is the actual change of the amounts themselves. Badly bungled examples of this method are shown in the accompanying half-tones, the change of amount from eleven to seventeen in the one, and from fifteen to twenty-three in the other, being easily apparent.

ALTERED CHECKS. ORIGINAL NAMES AND AMOUNTS REMOVED BY MEANS OF CHEMICALS

Another method of alteration—or a combination of methods already mentioned—is shown in the accompanying illustration. This is part of a promissory note which originally read two hundred dollars. A close inspection will show that a capital "T" was placed before the small "h" in "hundred" and the "hundred" altered so that with its prefixer "T" it reads "Thousand." An additional cipher added to the figures completes it.

ORIGINAL SIGNATURES ERASED AND OTHER SIGNATURES SUBSTITUTED

Alteration of Check by Maker.

Frequently checks are altered by bodily adding something to them after they have been returned to the depositor from the bank. It is, of course, but seldom that the amount of the check is changed in such a case. Usually the additions are explanatory of the supposed purpose of the check, as, for instance: "In full of account," "In full of all demands," "For interest on note," etc. In one such case I discovered that the pen in adding the words "In full of account" had slipped into one of the punch holes in the cancelling "Paid" perforated by the bank. As this cancelling perforation was, of course, made after the check had been paid, the ink marks inside the edges of the punch hole were proof positive that the writing was added after the check had returned to the depositor's hands, and not before, as the depositor would have had the court believe.

Another case hinged on whether the sentence, "In payment one gray horse to be right in every way" was written in its entirety at the time the deal was made, or whether "to be right in every way" was inserted at a later date. The entire sentence is concededly in the same handwriting, is written with the same ink, and probably with the same pen, but it was claimed by the defendant in the case that the phrase, "to be right in every way," was added the day after the preceding words were written. A reproduction of the disputed sentence is shown in the engraving.

ENDORSEMENT ADDED TO AT A LATE DATE

FROM $150 TO $1,150. NOTE IRREGULAR PERFORATION

Notice the difference in quality of line and slant between two portions of the sentence.

A Daring but Successful Method of Alteration.

One of the most successful methods of altering checks is to erase the entire amount—both letters and figures—and then to replace it with any sum that suits the "artist." This method is extremely difficult of detection if skilfully done, and is applicable to any kind of instrument. Even on safety papers a portion of the face of the check can be washed off by

ENLARGED SIGNATURES TO BOND SHOWN ON PRECEDING PAGE. ERASED SIGNATURE RENDERED VISIBLE BY PHOTOGRAPHY

A NOTE ORIGINALLY FOR TWO HUNDRED DOLLARS, RAISED TO TWO THOUSAND DOLLARS*

acid, the check be re-tinted as necessary, and then the desired amount be written in. This was the method pursued so successfully in the case of the Becker draft already mentioned.

The Value of Check Punches.

Check punches, while useful as a general protective measure, do not have any strong restraining influence on a professional check raiser. If you wish to know why, ask the agents of a check-punching mechanism to show you how they can raise checks punched by a rival machine.

The illustration showing the perforated $2,400 is a good example of a raised perforation. It was made from a photograph taken by transmitted light in order to show the original holes—now filled in—and the new perforations made thereafter. A casual, or even careful examination, under any ordinary conditions would not disclose the existence of the filled perforation.

The eleven hundred and fifty dollar check shown in another illustration is another example of a raised perforation. The original check, it is claimed, read "One hundred fifty dollars," this amount having been altered to read "Eleven hundred fifty." Notice the bad alignment of the punched figures.

Bad Writing as an Obscuring Element.

Indistinct writing sometimes plays as troublesome a part in obscuring the essential details of checks and others instruments as do actual alterations, confusing amounts, intention, and even ownership.

Some years ago I was consulted in a case of this kind. The question to be determined was whether or not the name in a deed as recorded was "Erving" or "Ewing" Jones. The original deed had long since been lost. The recording clerk was dead. There had been both an "Erving" and "Ewing" in the family. The descendants of both claimed the property. The difficulty lay entirely in deciding whether the writer had made the first part of his "w" like an "r" or had made an "r" like the first part of a "w." As the writer did not make the broad top "r" or a distinctive "r" with the "shoulder," it was very difficult to determine whether the property had really been deeded to "Erving" or "Ewing." An exhaustive comparison of the recorder's handwriting was necessary before the real ownership of the property could be finally established.

Alterations for Purposes of Concealment.

Occasionally, the endorsements of checks, drafts and vouchers are altered, either to cover up something, or to comply with some condition on the face of the paper.

Thus, in an investigation conducted in the office of the Borough President of New York some years ago, several vouchers for carpenter work were found which had gone through the Controller's office with very palpable erasures of signatures, and over-writing of signatures. In one instance, shown in the illustration, the camera brought out the signature as "Boyce." This was the real name of the party who signed, but his signature was affixed inadvertently. It was intended that he should sign a fictitious name. To leave the signature would have clearly shown that the contractor and an official in one of the city departments were one and the same. This was not desired, hence the original signature was erased and the name "Thomas A. Tydings" was written in its place. The original endorsed signature had also been erased and the name rewritten in a different hand, for somewhat similar reasons.

The Detection of Alterations.

In determining whether or not checks, drafts or other papers have been raised or otherwise altered, microscopical examination and comparison of the ink used in the written portions of the instrument will frequently determine whether or not more than one ink has been used. The fact that different inks were used in different parts of the check or other paper is not, of course, proof positive of fraud, but in the case of a suspected instrument is very strong presumptive evidence.

A microscopical examination of a doubtful instrument will often determine whether or not the calendering of the paper has been removed; also whether or not anything has been applied to the surface of the paper. Photographs, both by direct and transmitted light, will frequently disclose things not observable even under the microscope.

Where chemical erasures have been made and some of the original ink remains in the fibers of the paper, this ink—if it contains iron—may be partially restored by exposure to the fumes of acid in a tightly closed box. This restoration of the original writing is only temporary, fading in an hour or so, but it may be repeated as often as desired. While in the restored state, the original writing may be photographed and thus be permanently preserved.

Time as a Detective Agent.

When erasures on papers have been made by means of chemicals, these erasures can be, and frequently are, so well done as to defy detection at the time. But if the paper is examined again in six months it will usually show a decided yellow stain. And if photographed, the photo-print will disclose the stain emphasized, as the ordinary photographic plate is sensitive to yellow.

The Freedman checks shown herewith are good examples of chemically erased checks, photographed three years after the erasures were made. There were some thirty of these checks, amounting to about $25,000. The bookkeeper altered them by erasing the payee's name and substituting his own; and occasionally by raising the amount. In filling out these checks originally, the bookkeeper (who confessed to altering the checks and who has served a term in prison for the crime) wrote the payee's name, or the amount, whichever was to be changed, well above the base line. This when erased left the usual place for the name or amount clean and unaffected, so that the new matter could be written in with a free hand, without danger of blots or roughnesses.

In the writing on one of these checks, shown herewith, it is very difficult to discover any alteration; while in the other, shown in the same illustration, it is plainly observable.

Where erasures by mechanical means—abrasion for example—are made on papers that have been much handled or when a considerable time has elapsed since the erasures were made, they are much more easily detected than is otherwise the case.

The case of the State of New Jersey vs. James Connolly hinged—not on an altered check, but on substantially the same kind of erasure as is used in the alteration of checks. The alteration here consisted of the chemical erasure of a signature on a bail bond. The defendant was indicted for giving real estate which he did not own as security for a bond. He denied that the signature on the bond was his. And upon another inspection it was found that the name "James Connelly"—as it now appeared—was not in the handwriting of the defendant. As was discovered later, it was a new signature which had been written over a chemical erasure. In addition to this, a blot partly obscured the writing and made the work of discovering the true conditions much more difficult.

The defendant, on his part, engaged a handwriting expert who, upon comparison, reported that the "signature," as it now appeared, was not in his client's handwriting. The handwriting expert employed by the plaintiff then made photographs of the page and signature, natural size and enlarged, and at the trial these were introduced into evidence. They showed unmistakably that the original signature was "James Connelly" but written in a different handwriting from the second "James Connelly." This original signature as shown in the plate was brought out faintly but distinctly. On examination this original signature proved to be the signature of the defendant. The expert for the defendants thereupon left the courtroom without taking the witness stand. The illustration shown herewith is reproduced from the photograph used in court to prove that the questioned signature was in the defendant's handwriting.

The Prevention of Alterations.

A good ink, a good check punch, good safety paper and care in leaving no blank spaces will, as a rule, prevent raising of checks. It may not absolutely prevent alterations, but it will discourage the ordinary crooked operator—so much so that before exercising his art he will look around for a more careless writer who does not protect his bank account so well.

Lowering a Check.

I never knew of but one case where a check was "lowered." Here the forger stood near the window of a busy New York bank and saw a messenger from another bank present a check for certification. The messenger said that he would return in a short time. Before his return the forger stepped to the window, called out the name of the other bank, and was handed the certified check for some thousands of dollars. He had to act promptly and cash the check at once. Knowing the difficult of securing so large a sum without identification, he altered the check to read "Nine hundred dollars," cashed it, and escaped. He was never caught.

YOUR SIGNATURE AND HOW TO WRITE IT.

Identification by Handwriting.

Millions of dollars, frequently, and human lives occasionally, are balanced on a pen point.

No other record left by man is so peculiarly personal, characteristic, and identifying as his handwriting. It is better than photographs or body measurements for establishing identity, because it bears the stamp of the writer's individuality, his own personal touch. It can be recorded in compact form and can be easily filed and kept for reference.

No other nation produces so many good or fast writers as the United States, yet judging by the illegible writing, especially of signatures, we find many business and professional men who, with Hamlet, "Hold it a business to write fair, and labor much how to forget that learning."

A little more care and thought, especially in writing important papers, would save a vast amount of annoyance and even loss.

The three essentials of a good handwriting are legibility, ease of execution and speed. The greater part of the handwriting of this country is produced by the free, forearm movement. This is conducive to grace, speed, freedom and ease of execution, but not necessarily to accuracy of form.

Variations of Handwriting.

School children, following the same stereotyped models and practicing and using them under the same conditions, write very much alike, and this writing is crude, conventional, characterless. A few years out in the world works a wondrous change. Conditions and individual temperaments assert themselves, making alterations in the handwritings that leave them scarcely recognizable. A change of slant or size, a lopping off here, an addition there, an emphasis on a certain part of a stroke, the adoption of a new type of capitals, or small letters—these are some of the things that produce the variations found in handwritings that were originally almost identical.

"There is certainly a peculiar handwriting, a peculiar countenance, not widely different in many, yet always enough to be distinctive."—Boswell's "Life of Dr. Johnson."

These variations admit of almost an infinite number of combinations, and when these peculiarly personal variations from the normal or conventional styles become a fixed part of the handwriting of the individual, they are known as "characteristics," and serve as identifying "hall marks," or trade marks, as it were.

It is by these characteristics or hall marks peculiar to each handwriting that the particular handwriting is separated from all others and unmistakably recognized and identified.

These identifying characteristics are a combination of many conscious and more unconscious repetitions. Habits in handwriting may be formed as in other things, and by giving thought to it during the formative period we can control our writing and make it good or bad, characteristic or characterless.

A little study of our handwriting is not only interesting but profitable as well.

To-day a thing is hardly considered on the road to doing until it has been put into writing, and it behooves us to select what is for us the best style of handwriting, and a type of signature that will best protect the bank account and the other valuables safeguarded by signature.

The Signature.

A legal "signature" or sign manual may be an assumed name, a title, a mark, a sign or a pen flourish, anything that may stand for, or represent the name of the signer. Ordinary modern interpretation and use have construed the word "signature" to mean the writer's name written by himself. Hence the modern signature at a glance discloses: (1) the name of the writer; (2) his peculiar spelling of the name; (3) the various lines forming a pen picture of the same; (4) the writer's own personal technique or touch. This in its entirety gives an identifying mark that reveals at a glance sufficent of the writer's character to satisfy a hurried demand, and yields much more on longer and closer inspection. Then, too, "Age cannot wither, nor custom stale" its mark of identity. It will be the same to-day, to-morrow, next year, and until time affects the materials with which and on which it was written.

Style of Signature.

The object of every penman should be to select a style of signature, which while embodying his identifying characteristics, is also legible and easily and rapidly written. Such a signature is one which cannot, as a rule, be successfully imitated.

Details of Signature.

The first thing to consider is the spelling and any abbreviations of the name. If the name be John Henry Jones, it may be written J. Henry Jones, Jno. Hy. Jones, J. H. Jones, John H. Jones, etc. Select some one of these, and having once selected it do not change. It may be noted in passing that distinguished men rarely use abbreviations.

A married woman should sign her own name: "Susan R. Brown," not "Mrs. Henry G. Brown."

Next select the style of capitals and small letters you expect to use, and do not change because of desire for variety, or because of mere whim or caprice. The constant repetition of the same signature will give you skill, and a peculiar touch and technique that will be most difficult for a forger to imitate.

Select the kind of pen suited for your hand and for your writing. There is a wide latitude here; pens are made fine, coarse, stub, stiff or elastic. About

the only caution necessary is to select a pen that will not blur on the angles and short turns and thus hide some points of identity. Very broad stub pens are not good, and stylographic ("one nib") pens should be let severely alone. Never write with a lead pencil when any values are involved.

Writing the Signature.

While banks, as a rule, do not pay paper on the signature alone, still it is of prime importance to aid them all you can by giving them a signature that protects them and you at the same time.

A legible, rapidly-written, free, off-hand signature is much harder to simulate than an illegible, slowly written, or shaky signature. To successfully imitate any signature, the imitation must not only possess the correct form, but be written at the same speed as the original, otherwise the quality of line will betray the forgery. A poor penman cannot forge the name of a more skilful writer because the copy is beyond his skill. Forgers usually copy the signature of a poor or slow writer, as this requires less skill and gives more time while the pen is moving over the paper.

This has been found to be true in the majority of cases of forged signatures submitted by banks and attorneys to the writer for professional investigation.

So far as you can (and you can at your office) write with but one kind of ink.

Do not patch, mend or over-write a signature. This habit may deceive the paying teller when a forged check is presented for payment, bearing similar alterations. Do not depend alone on some little oddity, dot, dash or flourish, to redeem an otherwise bad signature and make it a safe one. A forger will readily see and imitate such things.

Even when the handwriting as a whole is neglected, the signature and figures should always be legible, since nothing can be judged by context to aid the reader. Each figure and each letter in a name should therefore stand out with perfect legibility.

A rubric or flourish is a good thing to add to a signature, as it is difficult to imitate. It should not, however, be allowed to obscure a legible signature. Have a rubric that does not extend too far below or beyond the letters, as space on checks is limited. The flourishes used to connect the letters in the name may be employed as a rubric.

If the initials of a name may be readily, gracefully and *legibly* connected, it is a good plan to do so. Some initials look better not so connected. Occasionally making one capital larger than another adds a distinctive touch to a signature.

Picket Fence Style.

Americans write illegibly not through ignorance or lack of skill, but because of a mistaken idea that an odd or illegible handwriting is difficult to imitate, or because of lack of time, or through carelessness. As an example, take the picket fence style of signature, used by some bankers and business men. It is by the general appearance of the picture as a whole that this style of handwriting must be recognized, and this fact makes it an easy style to imitate. One or two strokes more or less makes but little difference in the pictorial effect.

A story is told of the great lawyer, Rufus Choate, who was as famous for his bad handwriting as for his good law, that at a town meeting he threatened to challenge a voter because the man couldn't read but desisted on a bystander's threat to challenge the jurist because he couldn't write.

And Horace Greeley's letter of discharge of a composing room foreman for incompetence, which, because of its bad handwriting, was used as a recommendation to secure another job, is also famous.

Noted men may perhaps be allowed an illegible signature as a characteristic of their renown, and a tribute to it, but for the ordinary man of business it is not a safe indulgence.

The Ultimate Limitation of Mineral Resources

Its Significance to the Human Race

Prof. J. A. Kemp's Analysis

PROF. J. A. KEMP, in his presidential address before the New York Academy of Sciences, concludes his detailed consideration of the available sources of coal and the principal metals, with some very apt reflections of a general character. Incidentally, he considers the nature of the change which we may expect to come over the present social conditions, in the event that at some future time a scarcity should arrive in the supply of certain materials now appearing almost indispensable for the transaction of the great mass of daily business.

"Of iron ore there is no lack, nor need any one be apprehensive regarding the supply of this metal, but before very many years have passed the yield of the ore will have decidedly declined. While the falling off will be gradual, it will undoubtedly tend in the long run toward 40 per cent. This change is in itself important because, unless otherwise neutralized, it will raise the cost of production. It makes necessary the melting of more barren materials in the furnace, so that the consumption of fuel rises with respect to the amount of iron produced. It means also the mining and freighting of an additional burden which yields no return. From whatever point of view we regard it, other things being equal, the cost of production rises.

"The greatest cause of apprehension as regards present processes of iron manufacture lies in the supply of coking coal. We have built lofty furnaces, and in their use we place upon the fuel as it progresses downward in the furnace a heavy load of overlying ore and limestone. We need a very strong coke to stand up under the burden. The coals which yield these high-grade cokes are found in a small portion of the total coal-bearing area, and the life of the supply is one of the very serious phases of the present situation.

"While these physical and chemical factors operate to increase costs, there is always the possibility of improved processes of greater efficiency to keep them down. The improvement oftenest in people's minds to-day is the utilization of water powers to generate electricity, which in turn may supply heat. Now, in a blast furnace smelting iron ores, one-third the fuel is employed in reducing the iron oxide and two-thirds in developing the necessary heat for the reaction. Were we able with water powers to economically furnish electricity and from it derive the necessary heat we might save the two-thirds of the present amount of required fuel. We might reduce costs. The remaining one-third of the fuel we should always need, but it is possible that poorer grades than high-quality coke might answer. The saving would lie, of course, in the difference between the cost of the fuel and the cost of the electric current, provided the latter could be furnished more cheaply than the former.

"The water powers in our own country, or at least in the more thickly settled portions of it, have not failed to attract attention, nor have they gone altogether unutilized. The more conveniently situated ones are already harnessed to the dynamos. But in countries like Norway and Sweden, where there are large water powers still available, where there are rich deposits of ore and where coal fails, the applications of electricity to iron smelting are likely to be first worked out successfully. Data may be furnished in the life-time of many of us which will cast light upon these improvements in their world-wide relations.

"The only other apparent possibility of reducing costs lies in the labor charges. Wages at present are not unduly high, and unless the increasing population of the country brings to pass an inevitable struggle for existence, which will cause the greater subdivision of tasks at lower proportional returns, or unless the general reduction of expenses for subsistence makes lower wages possible, there would seem to be slight prospect of change in this item. In any event the reductions from this cause cannot compensate the falling off in the yield of iron.

"Suppose iron goes up in cost—other conditions of our daily life remaining the same—transportation and all manufacturing based on machinery would become more expensive; and less freely carried on. Undoubtedly an appreciable pressure would be developed to turn our people back to the rural districts and to tilling the soil for a livelihood. The tendency under the stimulus of manufacturing development has been the other way. The migration of late years has been toward, not from the cities. Shall we perhaps find, in the long run, in the increasing cost of iron and steel, a partial solution of a much vexed problem? Will the cry, "Back to the soil," receive support in a way not generally anticipated? The question is an interesting one for speculation.

"The general inference regarding copper is that the pinch of higher cost of production will be felt sooner than in the case of iron. We have no knowledge of such enduring reserves of copper ores as we have of iron. On the other hand, copper, despite its vast importance, is not the fundamental necessity that is iron. It is used in less quantity in machinery and its increase in cost would less vitally affect manufacturing industries based on machinery. Advancing cost would cut it out of much ornamental work of inferior esthetic merit. The most serious effect would be found in raising the expenses of service in the applications of electricity. Electrical transportation, telegraphy and telephony would be more expensive than to-day. Unless wireless methods of transmission eliminate copper, or unless some discovery in the domain of physics which we do not now foresee furnishes a substitute for the omnipresent copper wire of to-day, we may find ourselves face to face with some curtailment in these modern aids to the easy conduct of life's affairs. If in the course of several centuries the falling off in supply and the growth in population should raise copper to relatively high figures, we may wonder if a return in a way to the conditions of the Middle Ages will not result. Will copper then become to a greater degree than now the basis of skilled handiwork? Will the by-gone craftsmanship be revived and with a lessening total output shall we see an advance in artistic skill? In fact, if the vast development of machinery and the huge output of metallic objects at low cost—a condition so characteristic of to-day—should be checked or curtailed, would not hand-work on more valuable mediums of expression be restored? It is not altogether unreasonable to anticipate fewer objects and higher crafts in their production.

"The cases of lead and zinc are even more emphatic than that of copper. We have still fewer assured reserves and the pinch of increasing cost may manifest itself at an earlier date. The two metals are not, however, quite such vital factors in modern life as is copper and the larger effects would be less apparent. Zinc is a necessary component in the manufacture of brass, which industry absorbs the greater part of the copper output. A curtailment of either lead or zinc would cause inconvenience, but would scarcely occasion fundamental changes.

"Silver will be very seriously affected by a decrease in the output of either copper or lead. Gold will feel these changes in an appreciable but far less degree. There will always be sufficient, however, of each of the precious metals for coinage, and beyond this use their applications, except perhaps in photography, concern luxuries rather than fundamental necessities. We can not attribute to them any profound possibilities in their influence upon civilization should the contributions of the mines decline. In the recent past we have been more apprehensive regarding a too great supply of the precious metals, than regarding one too small.

"We can perhaps justifiably forecast a future in which agriculture will figure more and more prominently, and in which the moral, intellectual and spiritual life of the nation will readjust itself accordingly. Great and concentrated wealth is likely to be less in evidence, materialistic influences less pronounced, and from the vantage ground afforded by the greater comforts and opportunities of modern life as compared with that of a century or a half-century past, we may in the distant future look forward to an evolution upon somewhat different lines. Broadly viewed, the national life will probably be increasingly sympathetic with art and with ideals."

Increasing Use of Bamboo

THERE appears to be an ever-increasing use of the bamboo in the public parks and gardens of this country, where it bids fair to become a favorite ornamental plant.

The bamboo, generally speaking, comes from the Far East, notably China, where the bamboo reed is cultivated for exportation as well as for domestic use. On its native soil it is used in different ways. Its young shoots are eaten as a vegetable; its juice gives a sweet liquor like thin honey that ferments easily, so that it may be used as a beverage.

France carried the plant to Algeria, but the experiment was of no particular value. California's great plantations are fine examples of what can be done with bamboo under favorable conditions. As the great daily journals consume the forest timber, the builders turn to the woods used in home building in the tropics. In parks and in gardens, for seaside tents and for bungalows, the bamboo wood is especially adapted, being light, durable, easy of transportation and comparatively inexpensive.

France led the way in western utilization of the bamboo, but California will deserve all the praise if the bamboo supplants the high-priced timber hitherto used for building houses. In a climate like that of southern California bamboo reeds are ideal material.

Paris Oceanographic Institute

The Prince of Monaco's Splendid Foundation

By the Paris Correspondent of the Scientific American

OCEANOGRAPHIC work is among the most fascinating of modern science, and it may also be said to be among the most recent, that is so far as it relates to exploring the deep ocean bottom. By means of new instruments which are frequently being invented, we are able to bring to light many strange-shaped animals, some of these having a phosphorescent glow, whose very existence was unsuspected a few years ago. The Prince of Monaco gave a great impulse to deep sea sounding by building a special yacht, the "Princesse Alice," especially for ocean exploration, and has been carrying on this work for twenty years in the Mediterranean and other waters. The very valuable results which were obtained in the first expeditions of this kind led him to found a special oceanographic building at Monaco, overlooking the sea, and it contains many laboratories for use in examining all the finds which come in from the expeditions of the "Princesse Alice." After this institution, which we already have illustrated, had been in very successful working order for some time under the active direction of Prof. Berget, the Prince of Monaco conceived an idea which all scientists will consider as a most valuable and timely one, that is to found an oceanographic institution which should be specially equipped for this work and which should serve as a center for European research. For many reasons he was led to found the new institute at Paris, and it lies under the control of the French government. However, its scope is European and even world wide, as in connection with the institution there was founded a scientific committee, and this includes members eminent in the scientific world and selected from all countries, not forgetting America by any means.

PARIS OCEANOGRAPH MUSEUM, FOUNDED BY THE PRINCE OF MONACO

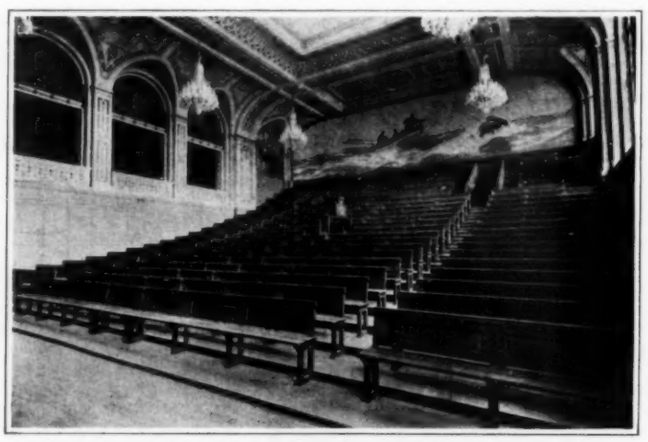
The Prince of Monaco endowed the institution with a fund of $800,000 in order to erect a suitable building at Paris and to carry out the needed arrangements. The object of the institution is to form a headquarters for oceanographic work which replaces the Monaco establishment, although the latter is also retained for aquarium purposes and to carry on such laboratory work and examination of new specimens which must naturally be done at a point lying near the sea. The Paris institution is reserved for research and educational work in oceanographic science in the different fields of geography, geology, marine animal life, etc. In order to interest the public in this science there will be collections on view both at Paris and Monaco, and at Paris especially are to be organized lecture courses on the same plan as university courses or others of a more popular character, often accompanied by lantern projections. The results of oceanographic work will be embodied in different publications which will contain papers written by scientists of all parts of the world.

The building, which our engravings represent, is a handsome one, and will provide roomy quarters for the laboratories and lecture halls. It lies in the University quarter of the town, on the old Rue St. Jacques, which was one of the great Roman roads crossing the city in ancient times, when Paris was scarcely more than a small island in the Seine. At present the new building is completed, and the laboratories are installed, so that it is soon to be in full working order. Lecture courses which are open to the public commenced in February. The building was designed by Architect Neriot, and is handsomely decorated with wall paintings by prominent artists. The Prince of Monaco's address at the inauguration, which took place amid a brilliant gathering representing the official and scientific world, was a warm appeal in favor of oceanographic research as being especially one in which the public as well as scientists would be interested. Moving pictures were then shown on the screen, and the audience followed the maneuvers of the "Princesse Alice," while nets or other deep sea sounding instruments were brought on board, or large fish captured by lines. Other views showed some of the strange-shaped animals in their movements, and the colored views of specimens taken upon autochrome photographic plates were a striking example of this new process as applied to science.

One of our views shows the main lecture hall, and especially to be remarked are the very handsome wall paintings, one of which represents the Prince of Monaco in the act of harpooning a porpoise. Others show the deck of the yacht when the specimens are coming in. Next to the main hall is a smaller lecture hall especially adapted for scientific courses, and each hall has a well-equipped projection lantern apparatus with a large screen. The building contains four stories, and on the ground floor is the council room, very tastefully decorated with deep sea paintings, followed by the assembly room, which contains a marble relief of the Prince of Monaco. The remaining floors are devoted to the laboratories. In the one which we represent herewith, Prof. Portier has charge of physiology of marine animals. Another laboratory is used for biology, under Prof. Joubin, and a third for physical oceanography, under Prof. Berget, who is at the head of the institution, and is also one of the chiefs of the Monaco establishment. Collections of specimens and also of various apparatus are to be one of the features.

We should say that in connection with each of the main laboratories, each professor has his own small private laboratory, in which he may carry on special work, while the main laboratories are open to persons who wish to enter, by paying a small fee, so as to follow the educational courses. However, these are intended only for scientists, and lie apart from the public lecture courses. In the basement, a large aquarium is installed for holding live specimens, and later on it will be one of the main features to be

ONE OF THE LABORATORIES OF THE PARIS OCEANOGRAPHIC INSTITUTE



MAIN HALL OF THE PARIS OCEANOGRAPHIC INSTITUTE

visited. Here is also an electric plant and a machine shop where special ocean work or laboratory apparatus can be made.

The English members are Prof. Bruce of Edinburgh and Prof. Buchanan of Cambridge University, also Sir John Murray, of the "Challenger" expeditions. We note also the name of M. Nansen, the well-known Arctic explorer. Among the French members, besides those already mentioned, are Prince Roland Bonaparte, Dr. Richard, the head of the Monaco establishment, and M. Yves Delage. Germany is represented by Drs. von Drygalski of Berlin, M. Hergesell of Strasburg, Drs. Chun and Hensen, and others, and in all there are thirty members, and many countries thus aid in the success of the enterprise.

Steel Cars for Passenger Trains

Designed and Built by the Pennsylvania Railroad Company

THE Pennsylvania Railroad has in service 764 all-steel cars of various types, and 358 cars now under construction. The company has gone further in the direction of the use of steel cars than most other roads. The Pennsylvania's policy in this respect was the result of a long period of inquiry and experiment in which the late President Cassatt took an active part. After several cars had been built the president appointed a committee of motive power officials to make a thorough report on the designs to be adopted, and the cars are now being built in accordance with the recommendations of that committee.

WOODEN CARS DO NOT MEET MODERN REQUIREMENTS.

The demand for passenger cars which would be stronger and better able to meet the severe conditions of service led to the consideration of other materials than wood for their construction. Growing scarcity of suitable timber and its rapidly increasing price played an important part in the development, since wood cars would soon cost as much as those of non-combustible materials.

TYPES OF CARS.

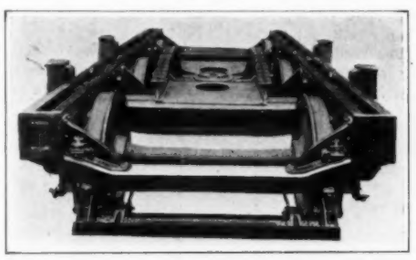
After carefully considering the problem from all sides, the Pennsylvania Railroad Company decided to adopt two types of steel passenger equipment:

(A) For through trains, drawn by steam or electric locomotives and composed of mail, baggage, sleeping, dining or day coaches. A long car of heavy construction suited to withstand the strain incident to pulling, coupling or buffing in long trains.

(B) For suburban trains, drawn by a locomotive or propelled by motors upon the truck axles; a short car of lighter construction well suited to operation in frequent short trains to accommodate the traffic.

REQUIRED STRENGTH OF FRAMES.

In preparing the designs for heavy type equipment great care has been exercised to provide ample strength to resist end shock of buffing or collision. Standard steel freight cars are designed to resist an end shock equivalent to 300,000 pounds compression. Experience with freight cars during the last five years indicated that this is not excessively high. An experimental determination of this figure was made by allowing a dynamometer car, weighing 51,000 pounds, to bump a number of loaded freight cars standing upon the track. The dynamometer registered 607,000 pounds. Another experiment was made by allowing a loaded steel freight car and the dynamometer car, weighting together 181,400 pounds, to bump a loaded freight car standing on the track.



THE NEW TYPE OF SIX-WHEELED TRUCK

The dynamometer recorded 400,000 pounds. In a collision between passenger and freight cars it is desirable that the passenger car should be the stronger in order to escape with as little injury as possible.

In computing loads upon the various members of the frame it has been decided that a compression load of 250,000 pounds between buffers, also 150,000 pounds between draft gear, is to be added to the normal loads due to the weight of the car and lading. Under these conditions the combined fiber stress is limited to 12,500 pounds per square inch for cars in through train service and 20,000 pounds per square inch for cars in suburban service. In determining these stresses none of the material above the belt rail is included excepting in the case of the horse-express car and the car designed for the Newark Rapid Transit Service, which have sufficient reinforcement above the doors to take care of the various strains. In the rest of the cars the sides beneath the window sills form girders about three feet deep, for which the belt rail acts as the top flange and the outside sill as the bottom flange. Owing to their great length, the thinness of the web, and the comparative shallowness of the flanges, these girders would probably collapse if subjected to end thrust. In calculations, therefore, the web and upper flange are not considered as resisting any of the 400,000 pounds load assumed to represent the effect of buffing.

The superstructure of cars is made strong enough so that they can roll completely over without danger of collapse. Posts, car lines and other parts are proportioned under this assumption.

The ends of cars are framed in such a manner as to resist end shock. Deck, or I-beams, forming the frame about the end door and securely fastened to both end frame and roof are proportioned with this idea in view. These features are shown in one of the accompanying illustrations.

TYPES OF FRAME CONSTRUCTION.

In the design of framing for steel cars two general types have been developed. One, in which the center sill is made strong enough to resist the end loads developed by pulling and buffing, in addition to the transverse loads due to the weight of under frame, superstructure and lading. The other type in which the plate girders formed by the sides of the car beneath the windows are relied upon to carry the transverse load due to the weight of the under frame, superstructure and lading. The center sill in the latter type is usually rather light, being designed to resist the end loads developed by ordinary pulling and light buffing. This type of framing follows the general form used in wooden cars where the transverse loads are carried by wooden trusses within the sides of the car reinforced by truss rods beneath the side sills.

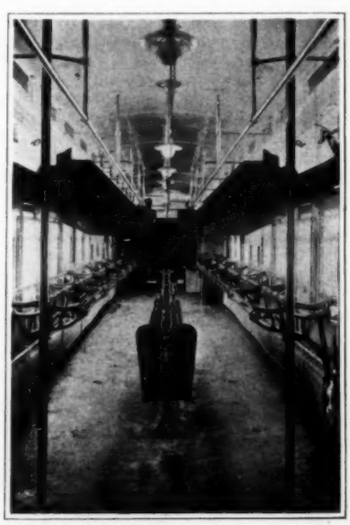
For through train service subjected to heavy buffing and pulling the center sill type of frame has been selected. It has also been used in designs for suburban type equipment, as it has been found that, with a modified form of center sill, sufficient room for motors was provided between the underframe and track.

DESIGN OF CENTER SILL.

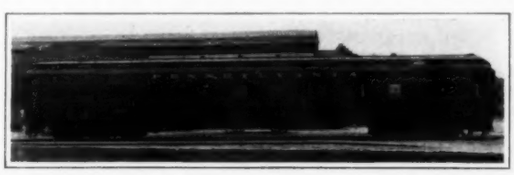
The height from the track to the center of coupler is determined by law, and the height to the top of the floor is practically regulated by custom. The center of the draw bar is, therefore, fixed at about 17 inches below the floor.

In wooden car construction the center sills are usually rather shallow and the coupler is supported below them. Loads upon the underframe, brought about by buffing, tend to bend down the ends of the car due to the fact that the center sills are not symmetrically loaded. In the steel car of the through train type the center sill is made deep enough to bring the line of coupler within its section.

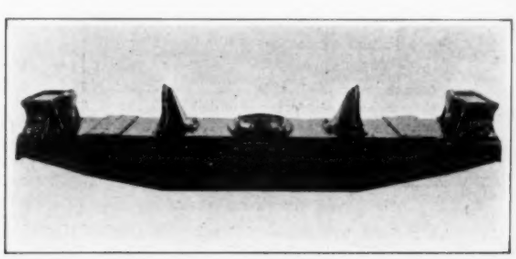
With the heavy center sill frame, body bolsters as used in wooden car construction are unnecessary, for the major part of the transverse load is delivered directly to the center sill which transmits it to the trucks through center plates carried on its under surface. The transverse loads which come upon the sides of the car and which must be transferred to the center girder are delivered at four points to equalize the loading. The center sill is a continuous girder, supported at two points by truck center plates and loaded with a practically uniform longitudinal load, which it carried directly, together with four transverse loads delivered to it from the sides of the car through cross bearers and body ends. The points of application of the concentrated loads are so selected that the two loads at each end are about equidistant from the center plate. Under this condition it has been possible to obtain in the center sill practically equal fiber stress at the middle and over the center plates, thereby securing great economy in the metal and avoiding the use of a center sill of deeper cross section at the middle than over the trucks. With the comparatively thin sheet steel metal, used in sheathing the sides and roof, it is of great importance to avoid unnecessary loading, as it is likely to cause loosening of the joints and working of the rivets in their holes. With this form of construction the side girders are made comparatively light as they, sustain little transverse load and are supported at four points. Side doors required by mail, express, or baggage cars can be located where most convenient without requiring any material strengthening in the side truss.



INTERIOR OF THE STEEL MAIL CAR



GENERAL VIEW OF THE STEEL CAR, SUPPORTED ON TWO SIX-WHEEL TRUCKS



STEEL BOLSTER OF THE TRUCK

INTERIOR OF THE PASSENGER CAR

The following table gives the comparative strength and weight of steel and wooden cars:

	Standard Wooden Passenger Coach 53 Feet Long.	Heavy Type Steel Passenger Coach 70 Feet Long.	Suburban Steel Passenger Coach 54 Feet Long.
Number of passengers	62	88	72
Car weight, pounds	*91,000	116,000	86,000
Car weight, per passenger, pounds	1,470	1,307	1,070
Area center sill at middle of car, square inches	152	50	24.32
Area center sill at center plate of car, sq. inches	152	50	38.32
Stress in center sills due to 150,000 pounds compression on draft gear and 250,000 pounds on buffer, per square inch	10,850	11,000	18,500
Comparative values of center sills, per cent	25	100	60

HEAVY TYPE 70-FOOT STEEL PASSENGER COACH.

In general arrangement and appearance this car is almost an exact copy of the standard wooden passenger coach.

Two 18-inch by 44.2 pound channels with ½-inch × 24-inch cover plates top and bottom form the center sill. Cast steel center plates are riveted to the under side of the sill, which is reinforced at these points by steel castings riveted inside. Projecting beyond each end of the center sill are steel castings designed to transmit directly to the center sill the loads due to buffing, and to support the spring rods carrying the vestibule buffer plates.

These castings are provided for the introduction of the vertical channels forming vestibule posts. Within the center sill near each end are riveted steel castings arranged to carry the couplers and draft gears.

The side sills are of 5-inch × 3½-inch × 9/16-inch angles. Each sill is supported at its end by end sills and at two intermediate points, about 14 feet from each end, by cross bearers.

The end sills are of the cantilever form, riveted to the center girder and built up of angles, the outside sheathing plate acting as the web.

The cross bearers, also of the cantilever form, and each composed of two triangular plates flanged about the edges, are riveted at their base to the center sills. Opposite cross bearers are joined by cover plates which pass over the top and under the bottom of the center sill.

Each side sill is held in line by nine struts of 5-inch channels connected to the center sill. These struts do not transmit any vertical load from the side sills to the center sill.

Cast steel side bearings for engaging the trucks are secured to the side sill in line with the center plates.

Pressed steel posts spaced 5 feet 11 inches centers support the superstructure. They are of channel section and the edges are flanged out and riveted to the inside sheathing forming a box section. Their lower ends are securely riveted to the outside sills and their upper ends are tapered down and bent inward forming lower deck carlines. At their upper ends these posts are riveted to the plate carrying the deck sash. The lower edge of this plate is bent out beneath the ends of the posts and forms a continuous beam of angle section running the entire length of the superstructure.

Between the main posts are shorter intermediate posts, which extend only from the window sill to the plate carrying the deck sash. They are of light channel section with edges flanged for riveting to the outside sheathing, forming thereby a box section.

Upper deck carlines are of sheet steel pressed to channel section with edges flanged out for riveting to the 3/32-inch steel roof plate. The ends of the carlines are riveted to the plate carrying the deck sash. The upper edge of this plate is bent outward and down forming a continuous beam of channel section to which the edge of the roof plate is riveted. Malleable iron braces unite the ends of each post and its corresponding carline.

The outside sheathing is of ⅛ inch steel, and the course below the belt rail is riveted to the outside sill and vertically to each post.

The steel shape forming the under sill for the windows laps over the side sheathing, and rivets passing through the belt rail, which runs the entire length of the car, secure this joint. The outside sheathing above the windows is riveted vertically to the posts and its upper edge is riveted to a channel-shaped steel section forming the eaves for the lower deck and extending the entire length of the superstructure.

The inside lining, including ceilings and bulkheads, is of 1/16-inch steel, to the unexposed face of which 3/16-inch asbestos is cemented. Molding, closely resembling that used in wooden construction, is pressed and drawn from steel, and its use adds greatly to the artistic appearance of the interior.

The window sashes are of wood and slide in a formed steel frame. Malleable castings riveted to the posts support the window frames. The window stops, which also form ways for the curtains, are of extruded bronze. The deck sashes are of malleable iron.

The floor is formed by corrugated or keystone steel plates which are supported by the center sill and upon longitudinal angles secured to the side posts. These plates are covered to a maximum depth of 1½ inches with a plastic surface filling, composed largely of cement.

A sub-floor of asbestos ⅝ inch thick supported by No. 20 galvanized sheet steel is secured to the center and outside sills.

Along each side of the car just above the floor rectangular ventilating ducts are provided which inclose the heating pipes and discharge warm fresh air into the car.

In the construction of the platform and vestibule an effort has been made to secure sufficient strength in the end of the car to prevent the superstructure from being swept off from the underframe by the next car in the event of a collision. The center sill is the main support of the entire vestibule, and to it are securely framed the 9-inch bulb angles forming the end door frame together with the 9-inch channels forming the vestibule posts. These vertical members are relied upon to prevent damage to the superstructure during collision.

The vestibule floor plate, the end sills and sheathing, and the vertical bulb angles are securely framed together to give an exceptionally strong foundation for the end construction.

The end of the vestibule is supported by two outside posts of pressed sheet steel together with two channel posts forming a doorway. The base is formed by a pressed steel platform end sill, and the top support is given by the vestibule ceiling plate.

SUBURBAN TYPE—54-FOOT STEEL PASSENGER COACH.

The general arrangement and appearance of this car are similar to the heavy type equipment, but the car is lower, shorter, and the space allowed each passenger is less than in the larger cars. The arrangement of seats has been modified to suit the traffic.

The underframe construction closely resembles the heavy type car, but in order to provide sufficient space for motors the center sill is made more shallow. It is formed by two 9-inch channels with a single ¼-inch cover plate on top and two ⅜-inch cover plates upon the bottom. This form of section keeps the center of gravity low and decreases the bending movement brought about by the fact that the drawbar is below the center sill entirely. The center plate is of special form adapted to reach the same trucks on heavy type equipment, and the casting, inclosing the coupler and draft gear, is attached to the under side of the center sill instead of being placed within it as in the case of the heavy type car.

The framing of the body is similar to that used in the heavy type coach, the main posts being identical except in the matter of length and shape at the top. There are three windows between main posts instead of two as in the heavy type coach.

STEEL SLEEPING CAR.

In order to complete the equipment of steel cars for passenger trains, the Pennsylvania Railroad Company has arranged with the Pullman Company to design and build some all-steel parlor and sleeping cars, of which 638 are now in service.

In both exterior and interior appearance they closely resemble the standard wooden Pullman car, except in the interior finish, where steel replaces the highly polished natural wood.

Steel is used for inside finish and is backed by asbestos to act as a non-conductor of sound and heat, except in cases such as the back wall of upper berth, the berth partitions and possibly a few other cases where non-inflammable composition material is used, as the steel is too cold to the touch.

The trucks are of standard Pullman type supplied with cast steel frames in place of the usual wooden members.

The principal dimensions of the cars are:

	Feet.	Inches.
Length over end sills	72	6
Length over platforms, coupled	80	6
Width over side sills	9	9¼
Width over eaves	10	0
Height over all	14	7

THE SIX-WHEEL TRUCK.

An entirely new form of truck was required for the steel cars, owing to the fact that the deep center sill of the underframe lowered the center plate until it just cleared the middle axle of a six-wheel truck. Advantage was taken of the opportunity offered for re-design, and a truck based upon a new principle was evolved which is applicable either to four-wheel trucks for motor cars, or four and six-wheel trucks for those drawn by locomotives. The new truck utilizes to the best advantage the valuable properties of steel as a structural material, is designed to carry a load equivalent to the maximum capacity of the 5 × 9-inch axle, weighs 21,000 pounds (which is the same as the weight of the old wooden trucks), but is considerably stronger. Transoms, spring plank and equalizers, though important parts in former truck designs, are not required, as their functions are covered by other elements in the new principle of design.

The accompanying illustration, page 377, shows the exterior appearance as well as the construction of the truck. Two elements are embodied; the rectangular frame carrying the wheels, and the bolster which transmits the load delivered at the center plate to the axle through the spring rigging.

The axles run in boxes of the usual type which slide vertically in pedestals, secured to the wheel pieces and connected at their bottom ends by pairs of tie bars (sufficient space being allowed between tie bars to permit the use of a jack in removing bearings). Each wheel piece is composed of two 10-inch channels (with their flanges turned toward each other) separated to permit certain of the working parts to go between them and secured to one another at intervals.

Two wheel pieces are held together by four pressed steel cross members of channel section, one at each end of the wheel pieces and one at either side of the middle wheels. They are depressed below the bottom of the wheel pieces in order to clear the center sill of the underframe.

The bolster is composed of four girders running crosswise of the truck to the top of which are secured two girders running lengthwise of the truck. The center plate rests upon two short transverse girders of pressed steel. The lower flange of these girders is turned up at the ends and the plate riveted to the lower flange is brought up and riveted to the longitudinal girders. Between the transverse girders is riveted a reinforcing casting to transmit the load delivered by the center plate. A horizontal rectangular plate forms the lower flange of both longitudinal girders and acts as a diaphragm to square the bolster. Spring beams are riveted to the under side of the longitudinal girders and to the rectangular plate which forms their lower flanges. They extend on both sides beneath the wheel pieces and are confined between guides, which allow only vertical and transverse motion of the bolster with reference to the truck frame. The spring beams are of sufficient width to admit between their downwardly projecting legs four elliptical springs.

The entire load borne by the truck is delivered by its bolster to sixteen elliptical springs which rest upon equalizers having a ratio of 2 to 1.

The equalizers are suspended from hangers, which deliver to each box of the middle axle one-sixth, and to each wheel piece one-third, of the entire load borne by the truck. This load is delivered to the wheel piece at two points near the outside pedestals, so that each box of the outside axle received one-sixth of the entire load borne by the truck. Each box receives its load through a nest of three helical springs which, in the case of the end axle, bear upon castings secured to the wheel pieces, and in the case of the middle axle, bear upon short equalizers connected to the hangers. The boxes of the middle axle, therefore, move up and down freely and without any connection or relation to the wheel pieces.

Side motion of the bolster relative to the wheel pieces provided by the hangers and guides is limited by abutments secured to the spring beam. Helical springs, resting upon followers guided by the wheel pieces and engaging the abutments, centralize the bolster and give easy riding qualities equal to those secured by the link suspension generally used on wooden trucks.

The outer abutments also act as side bearings for the car body and engage castings secured to the outside sills.

COUPLER AND DRAW-BAR.

It was found upon careful investigation that the standard form of draw-bar and coupler heretofore used on wooden cars did not allow sufficient side motion of the coupler head in rounding curves. The resultant binding was particularly noticeable upon long cars, and to remedy the defect an entirely new arrangement was devised by means of which a lateral motion of about 8 inches each side of the center was secured.

Owing to the large amount of side motion, coupler heads would interfere with steam and air pipe valves in their regular position. Projecting arms are provided on each side of the center sill at end of car for supporting these pipes, allowing them to move to clear the coupler on curves.

FOUR-WHEEL TRUCK FOR SUBURBAN TYPE COACHES.

Designs for a new type of truck for suburban service have been completed and trucks are now being built accordingly. This design is arranged in such a

manner that the same frame, bolster and detail construction may be used for either the motor or trailer truck.

The frame consists of two side frames which are composed of 8-inch Bethlehem H-beams equipped with cast steel pedestals at each end. A transom is rigidly attached to the side frames by means of corner gussets, and a bolster is placed inside of the transom supported on quintuple elliptic springs carried by spring carrier bars flexibly attached to the side frames. The transom corner gussets include the brake hanger fulcrums. The transom is made of pressed steel channel, shaped so as to permit the placing of the bolster between the vertical legs of the transom.

Stalactites

How they are Formed in the Laboratory and in Nature

By George H. Martin, M.A., F.C.S.

IT IS a matter of common experience in everyday life, says *Knowledge*, that when an article appears to be hopelessly lost, it is often found again in the process of looking for something else. So also in the domain of science, when experiment after experiment has failed in the search for the constitution of a compound for a method of preparing some substance on an advantageous commercial basis, or what not, the clue to the problem is frequently found in the course of an entirely different investigation.

In the case in point, for example, attempts were being made, in connection with a course of lessons in elementary geology, to prepare stalactites in the laboratory. The process seemed simple enough; all that was necessary, theoretically, was to allow a solution of bicarbonate of calcium to drop slowly from a small aperture and patiently to await results. Nothing, however, happened, although the experiment was tried in several ways. About the same time, for a different purpose, a burette full of lime-water was so arranged that the lime-water dropped from it with extreme slowness. This experiment also failed; but for some reason the apparatus was not dismantled, and the burette was left for some weeks with the lime-water still dropping slowly. When, however, the burette was again examined, it was noticed that a slight deposit was forming around the aperture of the nozzle, and it seemed just possible that if the process were allowed to continue a stalactite growth might form at the end of the burette.

And so it proved—a strange result when one considers that of the two experiments, one of which was started in the hope of making a stalactite, this was the one that was not begun for that purpose.

The growth of the stalactite was watched with much interest, and it proceeded with comparative rapidity. At the end of six months it had reached a length of one inch and a half, which means a growth at the rate of 1/150 inch per day. The stalactite grew in the form of a hollow tube, not quite straight but gently waved (see Fig. 1), and of approximately the same diameter throughout its length. The growing end of the tube was fringed with tiny fern-like projections which clasped the pendant drop as a jewel is grasped by its setting. Through a microscope it presented a beautiful appearance.

The projections were then seen to be fronds of crystalline growth—wonderfully fern-like in appearance and sharp in outline (see Fig. 2). The drops, which at the beginning of the experiment soon became milky, afterward remained perfectly clear the whole time they were forming; no separation of opaque calcium carbonate appeared to take place.

At the end of six months it was desired to show the stalactite at the annual meeting of the Public Schools' Science Masters' Association (January, 1910), so the experiment was stopped and the burette was emptied and carefully laid on its side. Then, with the point of a knife the "stalactite" was detached from the burette with the utmost care, and successfully introduced into a glass tube on a cushion of cotton wool, where it still remains. In appearance, it is a delicate, cream-colored tube of interwoven silky crystals, its whole weight being only one-fifth of a gramme.

The drops of lime water had fallen from the burette at intervals of about three and a half hours, making a total of eight drops, that is, about three-quarters of a cubic centimeter (0.046 cubic inch) per day. The drops fell upon a watch glass, where they evaporated to dryness, leaving a slight and apparently amorphous deposit.

It is interesting to compare the weight of the stalactite given above with the maximum weight of calcium carbonate theoretically obtainable from the amount of lime water used. Three-quarters of a cubic centimeter a day mean about 137 cubic centimeters (8.36 cubic inches) in six months (the burette was replenished as required from time to time), and since the solubility of calcium hydroxide in water at the ordinary temperature of a room is 0.14, the above volume of water will dissolve 0.19 gramme of calcium hydroxide at that temperature if a saturated solution is formed; and 0.19 gramme of calcium hydroxide contains 0.144 gramme of calcium oxide, which is equivalent to 0.257 gramme of calcium carbonate. The stalactite itself weighs 0.2 gramme; the difference being due partly to the fact that some of the stalactite remained adhering to the burette, and partly to the fact that some of the lime remained in the drop as it fell; and further, the lime water in the burette, even

FIG. 1

A Stalactite Forming on a Burette From Which Lime Water is Slowly Dripping

if fully saturated at the start, did not remain so, but there was always a certain amount of amorphous calcium carbonate precipitated from the solution, as may be seen at the bottom of the burette in the first photograph. The volume of carbonic acid gas required to form the calcium carbonate of which the stalactite is composed would be contained in about one hundred and thirty-three liters (35.13 gallons) of ordinary air. It might be noted here that the stalactite grew in a room which was only occasionally used, and for only short periods, so that the percentage of carbonate acid gas in the air would correspond pretty closely with the normal value.

So much for the facts: how do they compare with the generally accepted theory of the formation of stalactites, viz., that they are invariably produced by the deposition of calcium carbonate from a solution of bicarbonate of calcium? Here we have an obviously stalactitic growth formed by the dropping of a so-

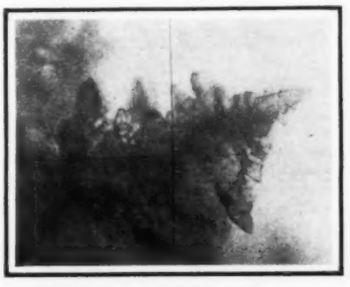


FIG. 2

One of the Crystalline Projections Which Clasp the Drop Shown in Fig. 1, as Seen Under the Microscope

lution not of bicarbonate of calcium, but by one of lime, so that an alternative method of formation seems possible. Do the conditions necessary for this alternative method ever obtain naturally? Is lime water ever dropping through the air in conditions similar to those in which it drops from the burette in the above experiment?

The answer to these questions is apparently yes. It has been tacitly assumed by geological writers that the stalactitic deposits formed under railways and other arches are produced in precisely the same manner as the stalactites and stalagmites of a lime-stone cavern. But is this so, at any rate in the earlier stages?

Is it possible for the whole of the lime—that is, for one-third or one-fourth of the whole bulk of the mortar contained in the two to three feet in thickness of brick, or stone work, which usually compose the masonry of a newly-built railway arch—to be changed into carbonate of lime by the time that the first signs of stalactitic growth appear? Apparently not, for according to Mr. Dibdin, in his "Lime, Mortar and Cement," the absorption of atmospheric carbonic acid gas by mortar, although at first rapid, gets gradually slower. "Mortars even centuries old are said to still contain appreciable quantities of hydrate of lime." This being so, it seems incredible that there could be any free carbonic acid gas available for dissolving calcium carbonate, at any rate in mortar under ordinary conditions; although it may be possible for the mortar in damp railway arches, through which rain water is constantly passing, to become saturated with the gas more rapidly. However this may be, the fact remains that this complete transformation is not necessary: stalactites of carbonate of calcium can be formed from lime water in contact with the carbonic acid gas of the air, and the general similarity in appearance between the stalactites of such bridges—hollow fragile tubes of approximately even diameter—and the artificially-formed stalactite described above, points to the conclusion that these stalactites and those of lime-stone caverns are due, at any rate in their initial stages, to quite different causes. In the case of the railway and other arches, the rain water percolating through the mortar must dissolve some of the lime, the carbonic acid gas in the rain water combining at the same time with another small portion of lime, thus rendering it insoluble in the water which has already lost its carbonic acid gas; so that the drops issuing from the under surface of the arch must consist practically of lime water. As shown above, lime water will form stalactites when allowed to drop slowly, so that stalactitic growth may start very shortly after the brick work has been put into position—as soon, that is—as the mortar in it becomes saturated with rain water.

That the explanation given above is the true one is supported by the marked difference in the method of growth of the two kinds of stalactites, viz., those formed from bicarbonate of lime and those formed from lime water. Sir Archibald Geikie, on page 475 of volume 1 of the new edition of his "Text Book of Geology," says, in connection with chemical deposits: "Of these by far the most abundant is calcium carbonate. The way in which this substance is removed and re-deposited by permeating water can be instinctively studied in the formation of the familiar *stalactites* and *stalagmites* beneath damp arches and in lime-stone caves. As each drop gathers on the roof and begins to evaporate and lose carbonic acid, the excess of carbonate which it can no longer retain is deposited round its edges as a ring. Drop succeeding drop, the original ring grows into a long pendant tube, which, by subsequent deposit inside and outside, becomes a solid stalk, and on reaching the floor may thicken into a massive pillar. At first the calcareous substance is soft, and, when dry, pulverulent, but by prolonged saturation and the internal deposit of calcite it becomes by degrees crystalline."

It is here clearly stated that the original deposit which goes to form a stalactite (whether in a lime-stone cave or under a damp arch) is soft and that it only becomes crystalline by degrees, whereas the stalactite formed from lime water grows by a *method of crystallization*, as may easily be seen in Fig. 2, which is a microphotograph of the growing point of the tube, in which the magnification is about thirty-eight diameters. It somewhat resembles, except in rate of formation, a "frond" of crystalline salammoniac, as seen growing on a glass slide under a microscope, and it is in striking contrast with the soft amorphous deposit of calcium carbonate one so often sees in lime water. Again, the deposition of the calcium carbonate, which goes to form a stalactite, as stated in the above extract, is due to loss of carbonic acid gas, and takes place at the "base" of the drop;

but as may be seen on an examination of the drop in Fig. 1, the "claws" of the crystalline growth nearly encircle the drop, and it appears almost as if the extension of this crystalline growth was due to and coincident with the absorption of the carbonic acid gas of the air by the lime water; a suggestion which is supported by the fact that the drop of lime water remains absolutely clear and bright through all the stages of its formation, none of the milkiness usually caused by prolonged exposure to the air being apparent.

It would be strange indeed if the causes of formation of the two kinds of stalactites should be of such an opposite nature, viz.: In one case the loss, and in the other the absorption, of the carbonic acid gas of the atmosphere, but one seems forced to that conclusion unless, as is just possible, both processes take place in the case of the drop of lime water, the gas being absorbed in the earlier stages of its formation and lost in the later stages, as the water in the drop evaporates; but if this explanation were the true one, the drop would be milky in the earlier stages of its growth, whereas, as already stated, this does not appear to be the case.

The "Olympic" and the "Titanic"*

Two Giant Ocean Steamships

THANKS to the courtesy of the owners and of the builders, Messrs. Harland and Wolff, we have been permitted to make a thorough inspection of the whole of the "Olympic" and her machinery as she now lies afloat off the fitting-out quay, situated some distance farther down Belfast Lough than the yard from which she was launched. Here she lies with a huge 200-ton floating crane alongside, and with her forward launching cradle still attached till she can be placed in the big graving dock, 886 feet long by 96 feet wide at the entrance, which is now under construction specially for her and her sister by the Belfast Harbor Commissioners. Drawing, as she does, some 14 feet less than she will do when fully loaded and equipped, her great height above the water does not permit her real size to be appreciated, though there is no doubt that she is very well named. Indeed, on expressing our wonder that two such typically White Star names as "Olympic" and "Titanic" had not been pressed into the service before, we learned that they had been specially saved up for some really worthy representatives of this mammoth fleet, which now amounts to 418,000 tons. We are almost tempted to express further wonder why this should be considered the critical moment for the bringing forth of these hoarded treasures in the way of nomenclature, and to ask what will happen when, judging from past history, the inevitable 1,000-footer comes along—and surely even then we shall not have the R. M. S. "Finalic"? It seems but yesterday that the names "Britannic" and "Germanic" were mentioned almost with awe as being the last word in steamship construction—certainly well within the memory of a generation; and yet our diagrammatic sketch, showing one of these boats together with the "Teutonic," launched some fifteen years later, compared with the "Olympic," shows that these wonderful old ships have been left far behind in point of size. One of the most striking of these elements of size is, we think, that of freeboard forward, which in the case of the "Olympic" is considerably more than double that of the "Germanic," and what this means in comfort and seaworthiness only those who have had experience of the comparative behavior of the big and little ships in a heavy head sea can appreciate. Another rather striking feature which is clearly brought out by the diagram is the comparatively insignificant increase in the amount of draught from the early boat, amounting to only 30 per cent, though the length is nearly doubled. Draught is, of course, likely to have a restraining influence on any further great increases in size for some little time to come, as its increase would entail very heavy expenditure in further dredging operations. The actual dimensions of the two new boats are:

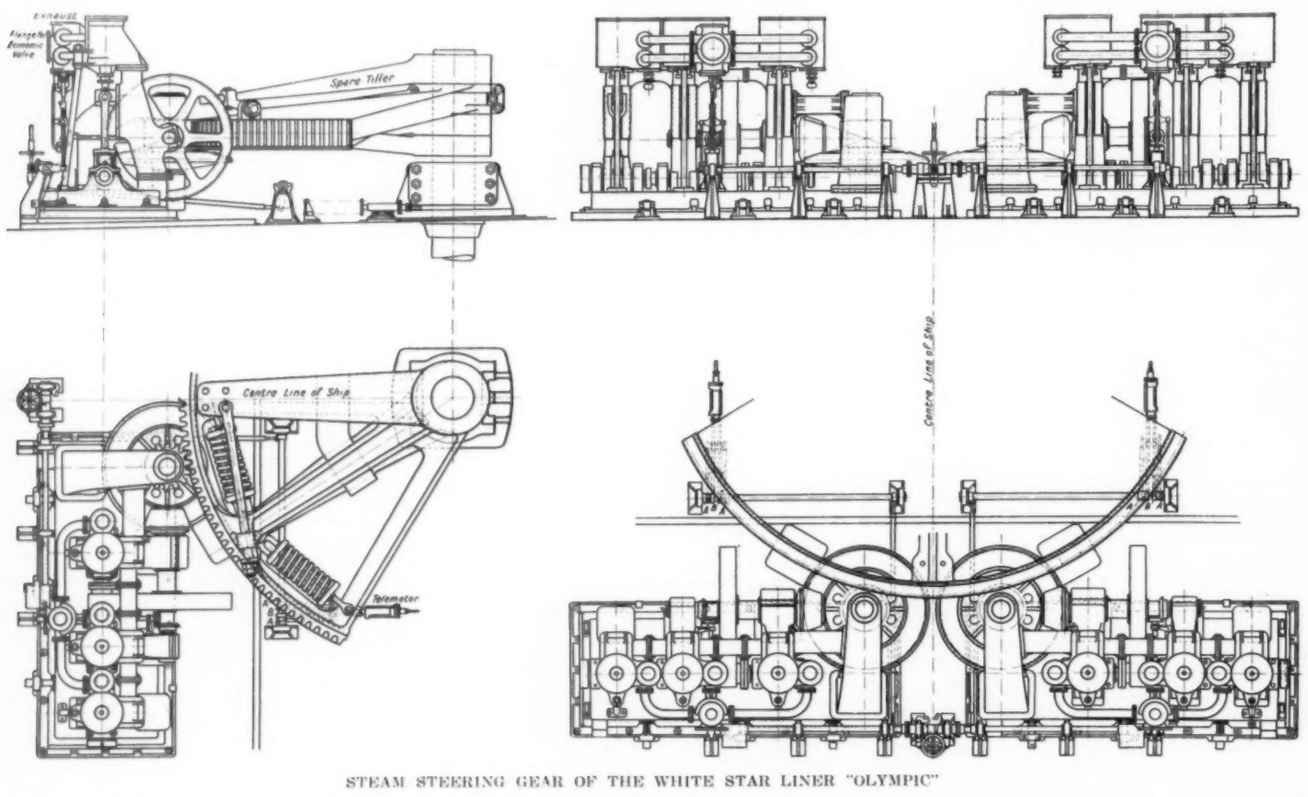
Length over all	882 feet 6 inches
Beam	92 feet 9 inches
Depth	97 feet 4 inches*

* Bottom of keel to boat deck.

Added to the above the following statistics may be of interest: Height of funnels above casings, 62 feet; keel to top of funnels, 165 feet; launching weight, about 26,000 tons; gross tonnage, 45,000; displacement, 52,000 tons; draught, 34 feet 6 inches; shell plates (largest), 36 feet long and 1⅛ inches thick; number of decks, 11; number of water-tight bulkheads, 15; capacity of double bottom, 5,700 tons; cargo capacity, 5,600 tons; number of passengers provided for, 2,500; crew, 850; while over 2,000 sidelights are fitted in the ship, and 16 boats are carried. It may further be noted that the smallest steamship ever built by Messrs. Harland and Wolff—71 feet in length—could easily be accommodated on the poop deck of the "Olympic."

Naturally, the designing and building of such a ship has called for many special appliances, such as the 200-ton floating crane mentioned above. This crane can lift a weight of 150 tons to a height of 149 feet at a radius of 100 feet with a list of only 4 degrees, while the small hook can lift 50 tons at a radius of 140 feet. While in the drawing office we noticed that the ¼ inch to the foot half-breadth model used for measuring off the plating plant was carried on a special worm and wheel elevating gear to enable the garboard and bilge strakes to be equally accessible for marking off with the sheer strake. A more fitting occasion on which to give details of the passenger accommodation will arise later on, but it may be of interest to mention here, that in addition to luxurious suites of rooms, there will be a swimming bath 33 feet by 14 feet, with a depth of water of about 9 feet; a squash rackets court 16 feet 6 inches high; electric passenger elevators, etc. The ventilation, too, will be carried out on a very elaborate scale, with a view to insuring perfect comfort and health below, even though the weather is so bad that ports cannot be opened or the passengers allowed on deck for fresh air and exercise. The heating will be designed as far as possible to suit the comfort of chilly passengers, or the reverse; air is drawn by means of a number of electrically driven Sirocco fans, through steam radiators, and delivered at a temperature of about 60 degrees, through trunks to all the saloons, state rooms, etc.; those who desire greater heat will find electric heaters in their cabins, by which they can roast themselves to their hearts' content. All the lavatories, galleys, etc., are, however, ventilated by means of suction fans of slightly greater capacity than the pressure fans, so that the air below is always kept sweet and fresh. The water closets and lavatories are arranged toward the center line of the ship, which, though complicating the pipe arrangement, allows of a greater number of outside cabins than on the usual plan. Throughout the passenger accommodation, the steel deck plates, which are joggled, are covered with Lito-silo, a composition accepted by the Board of Trade, which is fireproof, pleasant to walk on, and not slippery or noisy, while nails or screws can be equally well driven into it.

There are, of course, a great number of other matters of interest from a shipbuilding point of view, but we propose to confine ourselves henceforward to a description of the purely engineering features of the ship; these in themselves, as is to be expected, would demand a great deal more space than we can afford if we were to attempt to deal with them all in full detail, so that we shall endeavor to give a fairly complete and general description, and where possible dis-



STEAM STEERING GEAR OF THE WHITE STAR LINER "OLYMPIC"

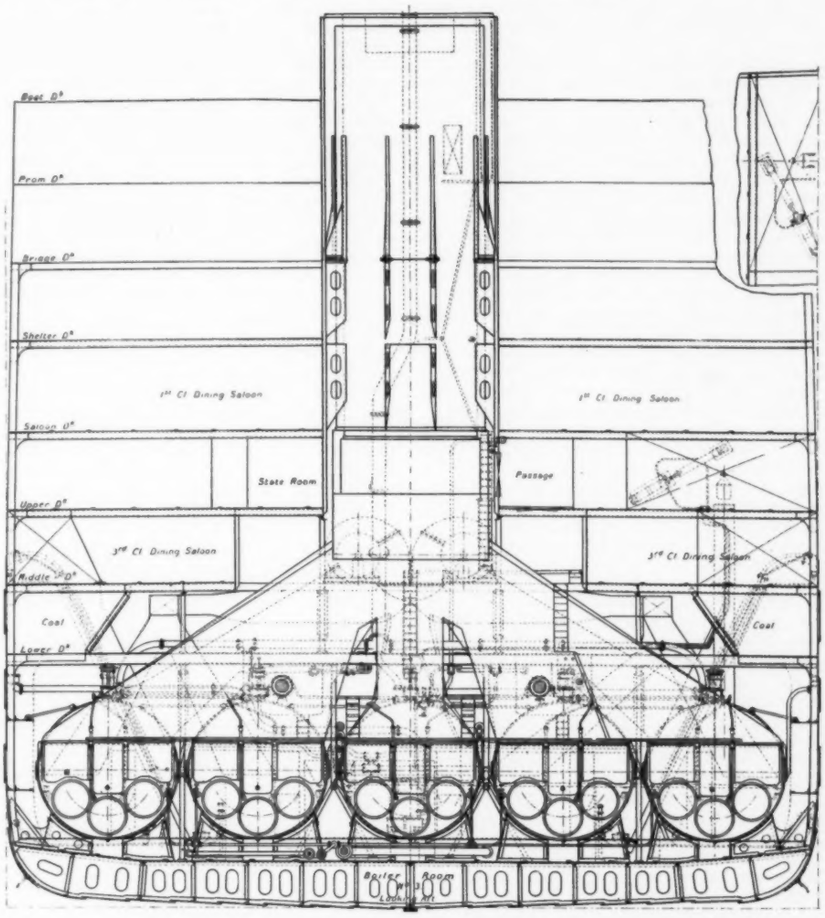
* *The Engineer.*

cuss the most interesting features, and not go into figures to any very great extent. By so doing we shall hope to avoid any resemblance to a mere catalogue of particulars, and so present our facts that they shall be of such general interest as befits a record of what may almost be called a national possession—as it is indeed to Great Britain that the credit, at all events, for such a wonderful production certainly belongs.

In spite of the vast range of machines to be dealt with there is no difficulty in knowing where to begin, as the feature which is bound to create the greatest interest is undoubtedly the adoption of the combination of reciprocating engines with a turbine, which has already been announced, an arrangement designed, as is well known, to secure the maximum possible economy, and which, we understand, has given remarkable results on the White Star liner "Laurentic." The engines have been already briefly referred to and described in our issue of October 21st, 1910, from particulars largely supplied by the builders, but in describing them now from a personal inspection we shall recapitulate some of the facts for the sake of obviating the need for constant references to a back number, and to make this article complete in itself.

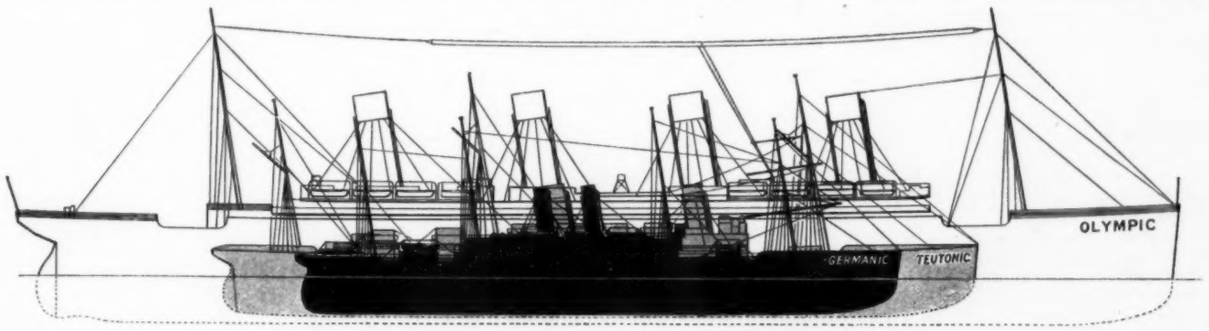
In designing the machinery for a transatlantic passenger steamer it will probably be safe to say that there are two main points to be considered after that of safety, namely, economy and the comfort of the passengers—that is, absence of vibration—and it is rather remarkable how well both these points are met by one and the same arrangement. The introduction of the low-pressure turbine allows the steam to be expanded down very much further than could be done in any reciprocating engine, and so economy is obtained, while its addition to a twin set of reciprocating engines enormously reduces the size of such engines compared with what would be necessary if only twin screws were adopted. As the vibration as it affects the passengers is largely a question of the total mass of the reciprocating parts in relation to the mass of the ship herself, it will be obvious that the smaller each set of engines can be made, the less will be the vibration felt by the passengers; so that there will be a point when the relation between ship and engine will be such that the reciprocating engine will cause no more annoyance to the passengers than would a turbine. Of course, the better balanced an engine is in itself the larger it may be in relation to the ship; so that in the case of the "Olympic," the engines, which are balanced on the well-known Yarrow, Schlick, and Tweedy system, are comparatively large. It is, perhaps, hardly necessary to add that the combination, while thus retaining all the advantages of a complete turbine installation, obviates its great drawback, and provides a ready and practically full-powered means of reversing.

Making this our opportunity for leaving generalities and coming to particulars, it will be well to begin by describing how this reversing is done, as we must admit that, before going fully into it on board, we anticipated that it would entail considerable complication and multiplication of duties for the engineer; but this is not so. The exhaust from each forward low-pressure cylinder is led out along the front of the engine into a steel T-piece on the after low pressure cylinder, where it is joined by the exhaust from that cylinder, and continues through the water-tight bulkhead. Here it enters an enormous "change-over" valve. One branch from this valve leads to the condenser, the other leads downward into a strainer some 9 feet deep and 5 feet in diameter, from the bottom of which a pipe leads at right angles to the low-pressure turbine; it is to be noted that the whole of this is in duplicate; and that there are two change-over valves, two condensers, and two steam admissions to the turbine. The change-over valve consists simply of what may be called a deflector piston in a casing; when the piston is up, the steam is deflected or guided downward to the turbine; when the piston is down, it is guided across the casing and out to the condenser. The pistons of both these change-over valves are interconnected through levers to a common Brown's hydraulic cylinder reversing gear on the bulkhead, which is controlled by a lever on the starting platform close to the main reversing lever. When the order to reverse is given, the engineer has simply to pull over his lever for the change-over reversing gear and pay no further attention to it; he need not even wait a second before pulling over his lever for the main engine reverse gear. The turbine will have been shut off altogether—except from the condenser—and the exhaust from the main engines will be passing direct into the condenser, so that the ship has become an ordinary twin-screw job, and will be handled as such without further reference to the turbine until she has settled down again for a straightaway run, when the change-over valve will be returned to its original position, and the turbine again supplied with low-pressure steam; the whole operation is simplicity itself. The design of the change-over valve is a very pretty piece of work, and must have required a great deal of scheming to get it into anything like reasonable dimensions—especially when it is considered that the bore of each exhaust pipe—which, by the way, is of lap-welded steel with a strap riveted over the weld—is no less than 5 feet. Expansion in a case like this, when everything is so heavy and so many rigid connections have to be made, is a matter requiring careful consideration, especially in view of the absolute necessity of excluding any trace of air from the pipes, which practically bars the ordinary stuffing-box form. The difficulty has been overcome by the provision of a number of concertina joints, one between each rigid connection, consisting of two thin steel disks, riveted to and about 3 feet larger in diameter than the steam pipes, and riveted together at their periphery through a steel ring; the flexibility thus provided by the steel disks is found to give ample "breathing" capacity.



WHITE STAR LINER "OLYMPIC"—BOILER ROOM NO. 3 LOOKING AFT

While on the subject of piping, it may be of interest to sketch the connections from the boilers. These are of welded steel, and in duplicate right up to the engine room bulkhead; here are the main stop valves, 21½ inches diameter, each with a large separator, and a cross connection which allows either range of piping to be used for either or both engines. Forward of this bulkhead on each pipe is a balanced emergency stop valve, which can be closed in a few seconds in case of need. In addition to the stop valves on the main engines there is an auxiliary valve of comparatively small diameter, but large enough to pass sufficient steam to run the engines at slow speed, so that this valve alone—which can, of course, be opened and closed quickly compared with the big stop valve—is used when handling the engines. Altogether, in spite of the non-reversing turbine and the huge size of the engines—cylinders, 54 inches, 84 inches, 97 inches, and 97 inches diameter by 75-inch stroke—the gentleman on the bridge ought to have no cause of complaint against the engine room when maneuvering this unwieldy charge. In the ordinary way a pipe arrangement would be considered a very dull subject, and



THE GROWTH OF WHITE STAR LINERS DIAGRAMMATICALLY SHOWN

would certainly not furnish material for more than two or three lines; but we venture to think that the installation under discussion presents sufficient points of interest to warrant our prolonging our description still further. After passing through the turbine the steam leaves the top of the casing through a rectangular hole on each side, and passes to the two pear-shaped condensers, the only auxiliary exhausting into the main condenser being the steering engine, to accord with White Star practice. Each of these rectangular holes is fitted with a big electrically-operated sluice valve, which will enable the turbine to be completely shut off from the condenser in case of damage to the casing. The eduction pipes are of welded steel, and extend from the sluice-valve casing out to the whole length of the condensers, so thoroughly distributing the steam over the tubes.

With the steam from twenty-nine big boilers to be dealt with, it may well be imagined that a lot of circulating water will be required, and this is provided by two circulating pumps with independent steam engines having cylinders 13 inches and 22½ inches in diameter—truly a decent little tug engine in itself. The hole in the ship's side for the circulating injection was in the case of the "Titanic," which we saw on the stocks, being used by the workmen as a means of ingress to and egress from the engine-room! After leaving the main engines the pipe arrangement naturally becomes inextricably mixed up with pumps, etc.; but we will try and follow the combination a little further. Copper pipes are used here, and generally for the smaller steam pipes off the main range, and we noticed in the shops that the edges of the copper used for big bends, etc., are chamfered off for brazing by means of a power hammer, which should help to produce good work. We were rather surprised to find that no higher vacuum than 28½ inches is expected from the four Weir dual pumps which are fitted, though within ¾ inch of the barometric pressure could probably have been reached if desired. The Weir arrangement has a single 22-inch diameter steam cylinder operating two 36-inch diameter pump cylinders connected together by a rocking lever; the one cylinder pumps the water to the hot well in the ordinary way, the other is connected to the upper part of one arm of a V in the air pump suction pipe into which the air and vapor rise and are drawn off, leaving the water pump free to work at its maximum capacity. From the hot wells two pairs of 14-inch duplex type pumps deliver to the oil filter and the surface and contact feed heaters placed in the reciprocating engine-room, the latter on the level of the saloon deck, and clearly shown in the elevation and cross section, whence the hot feed passes down with a good head to the four 19-inch main Weir feed pumps and so to the distributing valves on the engine-room bulkhead. It will be understood that the air, hot well, and centrifugal pumps and main condensers are in the turbine engine-room, while the main feed, together with the auxiliary condenser and numerous ballast, bilge, and sanitary pumps, and the two Hall's CO_2 refrigerators are in the reciprocating engine-room. There are no pumps whatever on the engines, and all are in duplicate, so that when four are mentioned it will be understood that two will be sufficient in the ordinary way to do the work. In addition to those auxiliaries already mentioned there are two turning engines, one auxiliary condenser and circulating pump, ash ejector pumps, three lubricating oil pumps, four Railton and Campbell ash hoists, twelve See ash ejectors, and three 60-ton evaporators, about ninety in all, together with others electrically driven which will be referred to later.

We trust we may not be thought to have attempted to cook our hare before we have caught him in thus detailing the pipe arrangement before we have got our engine in place, so to speak; but we think our description has up to the present maintained a fairly logical sequence. None the less, we had, perhaps, better retrace our steps and get ahead with a general outline of the main engines.

The low-pressure cylinders are arranged one at each end as usual with the balancing system adopted, and each has two flat valves worked off a common crosshead by a single set of double-bar links and eccentrics, and each having an ordinary balance cylinder. No doubt the two valves and crosshead result in a slightly greater total weight than a single valve, but this should be more than compensated for by the greater ease of handling and of maintaining steam-tightness. A single piston valve is fitted on the high-pressure cylinder, and two on the intermediate-pressure. In studying the engines of this ship we could hardly help being struck by the wonderful way in which the old link gear still retains its place in the favor of marine engineers, in spite of the many good radial gears that have been put upon the market from Hackworth, Joy, Marshall, Brock, and Morton onward; but at the same time we could not help feeling that, even if we were directly interested in any of these gears, we should have to admit that their chief claim to recognition—that of saving space fore and aft by bringing the valves out to the front of the engine—would in this case have very little weight, even though the steam distribution might be a little better; the whole space devoted to the machinery is simply enormous—in fact, it may be said that it extends for practically the whole length of the ship.

Certainly the impression gained in all three engine-rooms is one of vastness—vastness not so much of the machinery, though that is big enough, a cylinder column alone, for instance, weighing 21 tons, as of the space available for and devoted to it over 90 feet across! The electric light engine-room, for instance, to which we refer elsewhere, is bigger than many a big ship's main engine-room. However, to return. In spite of the big weights apparent, weight does not appear to have been wasted, and we noticed that the weigh shaft is tapered down in diameter outside the intermediate and high-pressure valve gears, where it has only a single set of links to carry. Each set of links, by the way, has its own separate adjustment, so that the Brown reversing gear may always be set at full stroke, whatever the cut-off required in each cylinder. Running at 77 revolutions per minute with a boiler pressure of 215 pounds per square inch, about 30,000 indicated horse-power are expected to be obtained, which with another 15,000 from the turbine at 165 revolutions per minute, should give the ship a speed of about 21 knots, though it is a curious thing that all the crack White Star boats have made their best passages at least ten years after their launch—the old "Britannic," if our memory serves us right, making her record after some twenty-six years' service.

An interesting problem arises in connection with the overhaul and examination of such an engine as this, where the built-up crank shafts weigh somewhere in the neighborhood of 120 tons each, and where a single nut off the bottom end is more than a man can conveniently deal with single-handed; the engine-room floors have had to be specially strengthened to receive such trifles as a main bearing cap, and altogether the engine seatings built up on the tank top are a study in themselves. Further, electrically operated lifting gear is provided on the tops for handling covers, pistons, etc., while below are electrically driven winches, with tackles, etc., for dealing with bearing caps, bottom ends, and eccentric straps. The turbine casing also has its own electric motor and lifting gear, while four machined vertical steel columns are fitted in guides on faces on the casting to insure its seating properly and without damage to the blades. In this connection we would draw attention to one point which struck us rather forcibly in the course of our inspection of this turbine—which is, of course, of the ordinary Parsons low-pressure type—though it is a point which is quite well known by now among marine engineers. We should incline to the opinion that the sea-going engineer would desire to make the same sort of inspection of the interior of his turbine—the rotor, etc.—as he does of the piston, valves, etc., of his reciprocating engine after a round trip. This, however, would be no easy matter, in spite of the splendid lifting arrangements which are provided, nor could it be accomplished in the length of time usually available at the end of an Atlantic trip. The number of joints to be broken, the size of the joints, and the need for absolute air, not steam tightness, and the weight of the various parts, eduction pipes, casing top, etc., which would have to be moved, would, obviously, involve several days' work, though we have no exact information on the subject, and it seems that the ordinary sea-going axioms may be permissibly, and in fact are safely ignored in the case of turbines.

An electric motor is provided for turning the turbine, though the reciprocating engines have steam-turning engines. The turbines were not built by Harland & Wolff, but there is now under construction at their yard an enormous new shop, the framework of which is of beautiful design, as combining lightness with strength, and the whole of this is to be given up to the construction of turbines in the future; in fact, the patterns for a set have already been constructed. No less than fourteen collars are fitted on the thrust shafts of the "Olympic," which, with the line shafting, are hollow, a 9-inch hole being bored from end to end. Loose couplings are fitted on the tail shafts of the reciprocating engines to enable them to be withdrawn outboard for examination—a very necessary arrangement for a 28-inch shaft. There are eleven plummer blocks on the turbine shaft, all of which are provided with forced lubrication at a pressure of about 28 pounds per square inch, obtained by gravity from a tank high up in the turbine engine-room, holding a ten minutes' supply in case of failure of the pump. The oil escaping from the bearings is collected in special drain tanks and pumped through strainers and coolers back to the gravity tanks; the tubes of which these coolers are composed are flattened into an oval just beyond the point where they fit into the tube plates, and it is found that the oil does not tend to harden on the surface as was the case with circular tubes, a very cheap and simple method of getting over the difficulty.

The days when the engineer had to stand by the throttle and do his best to close the valve at the correct moment to prevent racing, and open it again in good time to allow the engine to get away when the propeller again became immersed, are, of course, long since gone by, and the well-known Aspinall governor is fitted to make a thoroughly good job of what a man at the best could only make a poor job of; fitted on a special rocking arm in the absence of the usual air pump lever, this is connected to the throttle of each engine, and forms a very perfect mechanical governor, while the turbine is similarly cared for by means of a ball governor acting on the Brown's gear which operates the two change-over valves, so that in the event of a fracture of the turbine shaft, or loss of the propeller, the turbine would be shut off and the reciprocating engines would go on their way with unruffled serenity.

As is probably well known, the White Star Company only permits the use of forced ventilation, and not of any system of forced draught, on its ships, and though this tends to increase the grate area necessary, yet with a height of funnel of 150 feet above the bars there cannot be much difference between the two, with the advantage of induced instead of forced draught. It is rather curious to consider what a great advantage from a steam producing point of view is this great height, which is, after all, rendered necessary, strictly speaking, solely by æsthetic demands, and by the desire to obtain a smart looking ship, of which the proportions shall be well balanced; the top weight, however, of four oval funnels 24 feet 6 inches by 19 feet, and over 70 feet above the boat deck, with their inner casings, must be enormous. The boilers themselves are twenty-nine in number—twenty-four double-ended and five single-ended, each 15 feet 9 inches in diameter, the former being 20 feet long and the latter 11 feet 9 inches, with plates 1 11/16 inches thick, the shells having only one joint. The comparative insignificance of the battery of boilers in relation to the ship is illustrated by the fact that the boilers are placed in the ship no less than five abreast, although actually a walk from end to end of the boiler-rooms is a big undertaking. Thwartship bunkers are placed between each pair of boiler fronts, with a bunker door opposite each boiler, so that trimming on the plates is reduced to a minimum. The wing bunkers are above the level of the boiler tops, each wing boiler being secured by rolling chocks direct to the skin of the ship. Even the uptakes on a job like this are a source of wonder; they are even, in fact, provided with expansion joints.

Naturally in such a ship many interesting little "gadgets" are to be found in the course of a tour of inspection of the stokeholds and elsewhere; for instance, each stokehold is provided with Kilroy's stoking indicators, one for each boiler—neat little electrically operated signal disks with loud gongs, which give visible and audible intimation to the fireman as to the exact moment when each furnace is to be fired. The instruments are so arranged that there shall be the minimum number of doors open at the same time, and no two opposite doors in the same double-end boiler shall be open together. The interval between the times of firing any one furnace are under the control of the engineer, and can be varied if found necessary, but when once set insure perfect regularity of firing, and so promote economy and smokelessness. The current is provided by the ship's circuit, so that when set and the switch opened, the gear is automatic, and requires no further attention.

Even the whistle arrangements, embodying as they do a device designed by Mr. W. J. Willett Bruce, of the White Star Company, to insure a supply of perfectly dry steam immediately the whistle is required, are out of the ordinary, though they are what are now used on all the White Star boats. An automatic non-return valve having a drain leading into the exhaust system, is fitted in the whistle valve casing, so that there can be no accumulation of water to sputter and muffle the sound when the lanyard is pulled, and a clear blast immediately follows. In addition to this, an electrically controlled timing apparatus operated by current from the lighting circuit is provided by which the whistle can be blown at perfectly regular pre-determined intervals in order to comply with the Board of Trade regulations for signaling in a fog, so relieving the tension on the nerves of the passengers, and reducing the duties of the officers of the watch. Another provision toward safety is the rather obvious arrangement for controlling the closing of the water-tight doors in the bulkheads. These are kept open by means of a clutch kept in engagement by a weight.

This weight can be lifted by an electric arrangement operated by a float in the bilges, so that any water accumulating below the floors to more than a predetermined depth will raise the float, release the clutch and lower the door—this taking place comparatively slowly owing to the pneumatic cushion cylinder on the bulkhead having its piston connected to the door. There is also a hand control by which a man who might be trapped below could delay the closing of the door till he had made good his escape. These little points are detailed to show the care and thought which have been expended in even the smallest items of the equipment of the ship.

There are also Silley wedge action smoke-box door fasteners which do away with the usual many handles and tend to keep the doors from warping; a complete outfit of telegraphs to indicate the requirements of the engine-room in regard to steam, etc., while each stokehold has its own pumps in their own little engine-room completely screened off from the coal dust. Some 176 firemen will be carried, with 72 trimmers, and these have their own special passage and spiral staircases leading to their bathrooms and quarters, so that they never need be seen by the passengers while on their way to or from duty. We should not omit to mention, too, that there is a series of escape trunks leading from the engine-rooms and stokeholds to the upper deck to enable the men to escape in case of the ordinary means of egress being rendered useless by accident.

THE ELECTRICAL OUTFIT.

Those who remember the early days of the introduction of electricity on board ship, when any old otherwise useless corner was good enough to stow the dynamo in, would appreciate the great importance to which this department has now attained on board ship by an inspection of the palatial room devoted to the generating plant on this ship. The whole width of the ship—except for the space taken up by the three shafts and their plummer blocks—for a length of some 64 feet and 24 feet high is entirely given up to it. Here are situated the four sets of 400-kilowatt multipolar dynamos, each driven by a three-cylinder compound vertical inclosed "Allen" engine, having cylinders 17-inch, 20-inch, and 20-inch diameter by 13-inch stroke, running at 320 revolutions per minute, with a steam pressure of 180 pounds per square inch. Forced lubrication is, of course, used, with special arrangements to prevent the oil getting into the cylinders and so to the boilers, and we were interested to note that Renold silent chains instead of belts were used for driving the tachometers, and that watt meters are fitted to each set. It may be mentioned here that, in addition to these four sets, there are two 30-kilowatt sets having cylinders 9-inch and 12-inch by 5-inch running at 380 revolutions per minute, fitted on the level of the saloon deck above the water line, so that if the main generating room were flooded it would nevertheless be possible to have sufficient light to avoid panic among the passengers and for signaling purposes, etc. It will naturally be asked why reciprocating engines have been adopted for the dynamos instead of turbines, and this question received very careful consideration on the part of the builders, and is largely a commercial rather than a mechanical one. The whole of the exhaust from these engines was required for the feed-water heater, so that the economy of turbines would have been seriously interfered with, and this favored the adoption of the reciprocating engines.

The whole of the installation has been most carefully thought out, complete wiring plans having been prepared giving the position of every switch, light, and motor throughout the ship, and what this involves may be guessed from the following list of machines for which electricity is used, in addition to the arc and incandescent lights: Deck cranes, cargo, boat and engine-room winches; Waygood's elevators for first and second-class passengers and lifts for stores, mails, and pantries; eight 55-inch, two 50-inch and two 40-inch stokehold fans, delivery fans for cold, hot, and warm air; cylinder lifting gear, turbine turning, and turbine lifting; pneumatic conveyor, Marconi apparatus, gymnastic apparatus, ice rockers; domestic machinery such as dough mixers, potato peelers, roasters, knife cleaners, slicers, whisks, etc.; sluice valve operating gear, steam whistle, sounding machines, illuminated signs, clocks, water-tight doors, helm indicators, submarine signaling, wireless telegraphy, telephones (loud speaking and ordinary), bells, cabin fans, heaters, hot plates, and similar appliances, electric irons, and electric baths. The total number of motors is between 140 and 150 from ½ to 40 brake horse-power, while there are 450 heaters from 750 to 2,500 watts each.

The dynamos are compound wound, the equalizer cables being led to interconnecter switches situated below the deck at a position approximately equidistant from the four machines, with a view to minimizing and equalizing the resistance when running in parallel The positive cables run to the main switch pillars, and thence to the "feeder panels," or switchboard proper, which is placed athwartships on a raised platform or "organ loft," which runs right across the ship, arranged as it is to distribute some 20,000 amperes at 100 volts—equal to the central station of a good large town; the heating, lighting, ventilating, and power each account for about 25 per cent of this. The adoption of tantalum lamps, which are fitted throughout (with the exception of some ordinary incandescent lamps in the engine-room), permitted the voltage to be reduced to 100, which, it is estimated, will result in a great economy, in spite of the higher cost of the metal filament lamps. The latter have been found to be quite suitable for use on shipboard, except where there is any pronounced vibration. On this same platform are arranged the four main switches, and contact breakers, above mentioned, one for each dynamo, the levers of each, of which there are five, being interlocked, so that only the correct sequence of operations can be carried out. The operator faces the generating plant, and has under his control an illuminated sign actuated by a round handle, by which he can signal to the engineer in charge of the generating plant for more or less speed, or for a given machine to be started or stopped. The whole switch when completed is, of course, completely cased in by planished steel sheets. All switches, etc., are connected to illuminated and numbered signs, so that the effect of the movement of any lever is clearly and unmistakably indicated. From the feeder panel 46 leads of 91/13 cable are carried together with their returns, in two steel water-tight trunks through the various decks; distributor boxes are fitted on each deck from which the leads are sub-divided to the various circuits, so that all the wiring is kept as compact as possible; all wires leading through a water-tight bulkhead are collected together in a steel tube filled with bitumen for the sake of neatness, while maintaining water-tightness. We noticed a neat method of leading the cables to the stokehold fan controllers. The cables are fitted permanently into screw plugs, the holes for which are bored and tapped in the joint of the cover, so that they can be placed in position, and the cover screwed down, making a simple and yet water-tight joint. These controllers, by the way, have rods supported on ball thrusts leading down into each stokehold, so that they can be operated either from above or below; the ball thrusts enable the gear to work with so little friction that the different positions on the controller can be easily felt even at the bottom end. While on the subject of electricity, we would like to draw attention to the method adopted for lighting the ship while being fitted out. The whole of Queen's Island is covered by cables leading from the main generating station in the works, but the "Olympic" is lying beyond the reach of these, so the firm have installed four dynamos on the main deck of their tug, the "Jackal," which is lying alongside, and have made her into a portable central station supplying the whole ship; a fire engine has also been installed with hydrants all over the ship, and fire drill is carried out once a week. This, with the big floating crane and the special steel gangways already referred to, is suggestive of the huge capital outlay to be considered in the construction of such a ship, which alone puts the work beyond the reach of all but a few firms.

OTHER AUXILIARIES.

There is, of course, much other auxiliary machinery in all parts of the ship, but we will only refer to some of the more important items.

In order to keep the weight of the anchors down as much as possible, and yet to comply with the Board of Trade regulations, an unusual arrangement has been adopted in having a hole in the stem to allow for a third anchor, which is housed on the forecastle, the two side anchors housing in the hawse pipes as usual. Two large vertical steam windlasses by Napier Brothers are provided for the side anchors, the starboard one of which has additional clutch gear operating through bevels to a worm and wheel on a large central drum grooved to take the huge steel wire which is fitted to the center anchor instead of the usual cable; the thrust block on this worm shaft is quite a striking piece of machinery, and gives some indication of the power required for dealing with this important part of the ship's equipment. The big anchor weighs some 15½ tons. Two warping engines are also fitted under the forecastle, which in itself forms a small engine-room.

Right aft we were faced with a feature of which we are afraid we could hardly appreciate the precise value, or at any rate, the value commensurate with the cost involved. Here we found a pair of enormous three-cylinder steam steering engines of the firm's well-known make. Only one set is in gear at a time, the other set being a stand-by, which can be quickly engaged by means of screw jacks embodied in the framing, which slide the base plate along for the distance necessary to engage the teeth of the pinion in the rudder quadrant, the bends in the steam pipe being sufficiently flexible to allow of this without the need for making any joints. We should have thought that the rudder head would have been more likely to prove the weak spot, failure of which would, of course, render both engines useless, while the ship could be safely navigated into port by her propellers only. However, perhaps it is not for us to criticise a feature which a firm of such enormous experience as the White Star Company has apparently found to be desirable. The gearing of the engines is of the double helical or herringbone type, cut from the solid—Citrön gear. It is designed for silence and strength, and we were informed that it is perfectly noiseless, and entirely does away with backlash. The pinion on the gear shaft meshes with the teeth on the quadrant, which is loose on the rudder head, but the quadrant is connected by springs to a double tiller below, which is keyed to the rudder head, so that the engine and gearing should be relieved of all shocks, which, in view of the fact that the rudder weighs 100 tons and is 15 feet broad, will not be inconsiderable. An emergency tiller is also fitted, which can be connected up to the two warping engines in the wings, in case of damage to the quadrant, the teeth of which are in interchangeable sections bolted to the casting. The control is by means of a Brown's telemotor from the bridge actuating the steam valves. There is also fitted a Brown's Economic valve—or "get-out-of-the-way valve," if we may be allowed to coin a word—to prevent leakage of steam while the engine is standing, due to the absence of lap on the piston valves. This valve consists of a conical-seated valve in the steam admission port, with a coned projection extending into the engine valve chest, and when closed shuts steam completely off the engine. When the engine valve is moved by the telemotor it acts on the coned projection and pushes the valve back off its seat and admits steam, a strong spring returning the valve to its seat when the engine valve has resumed its central position. We understand that the engines are capable of putting the helm from hard-a-port to hard-a-starboard in twenty seconds.

Though it is practically impossible and not always desirable to describe all the details of such a mammoth installation as this, we think we have outlined the main features of interest without dwelling upon points which are matters of too common knowledge. For instance, we have given no description of the turbine, as details of one set such as this are common to many others which have frequently been described in recent years, and a Parsons turbine does not present so many possibilities of design as a reciprocating engine—at all events outwardly. To go over such a ship while under construction is a liberal education in itself, and affords a better idea than could the completed ship of the wonderful organization necessary to enable the swarms of men employed in the ship construction, engineering, electrical and other branches, to work synchronously and harmoniously together in the rapid completion of the whole structure.

Temperature and Humidity of Workrooms, Etc.

THE effect of different temperatures and degrees of humidity in the air in different workrooms, mines, etc., has been tabulated by a German, who sums up his observations and recommendations as follows:

At a temperature of 10 deg. C. (50 deg. F.) the worker is liable to catch cold if not protected specially by warm clothing. If the work is severe physically and the body thereby greatly heated, a temperature of at least 12 deg. C. (53.6 deg. F.) is necessary for comfort and health. If a lower temperature is unavoidable, then thick clothing is necessary. If the work is physically less exacting, with ordinary clothing 18 to 20 deg. C. (64.4 to 68 deg. F.) and about 40 per cent of saturation is right. Miners, tunnel laborers, bakers, etc., who are compelled to work where the temperature is 30 to 56 deg. C. (86 to 132.8 deg. F.), with humidity 60 per cent and even over, are in danger of heat-stroke, unless special precautions be taken to prevent it. For temperatures over 50 to 60 deg. C. (122 to 140 deg. F.), where the air is dry—say with humidity 20 per cent—as is the case with glass blowers and distillers, the work is not so exacting by reason of the low degree of moisture.

The two sets of workmen mentioned last should as far as is practical strip for their work, and should enjoy good ventilation; also should use heat veils and screens.

Airship Anchorages.

By MAJOR O. C. VON VERSCHUER.

THE airship cannot become a practical means of transit until its safety has been assured by an organization as thorough and comprehensive as those of railways and steamship lines. Airship harbors and anchorages are especially necessary. The loss of the stately passenger airship "Deutschland" was due to the lack of suitable anchorages.

The peculiarities of airship traffic will probably develop stations of three classes:

1. Terminal stations, analogous to railway termini

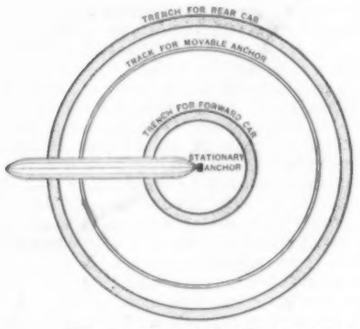


Fig. 1.—Plan of Airship Anchorage

in large cities, and provided with shelters or sheds and every requisite for the preservation, maintenance, equipment and repairing of airships.

2. Way stations at suitable points in the vicinity of small towns and villages.

3. Emergency stations in places well sheltered from the wind, such as valleys surrounded by forests, and situated, if possible, near towns and villages.

Costly shelters will not be required at way stations, for the stops at these stations will usually be short, and even a longer stop, caused by adverse winds or a disabled motor or propeller, will not necessitate the housing of the airship, if the anchorage is provided with appliances which will assure the safety of the vessel even in a violent storm.

An anchorage suitable for a Zeppelin airship can be constructed as follows: The vessel is secured by a stationary anchor, placed at the center of a sheltered level field about 1,000 feet in diameter, and also by a movable anchor in the form of a wheel, rolling in a hollow circular track, about 250 feet in diameter. The stationary anchor is attached to the bow, and the movable anchor to the stern of the airship, which, therefore, automatically keeps it head to the wind.

In order to allow the bottom of the cylindrical hull to be brought very near the ground, two circular trenches, 6 or 7 feet deep, and concentric with the anchor track, are provided for the reception of the two cars, which move along their respective trenches as the airship veers with the wind. On account of the downward pressure of the wind, the bottom of

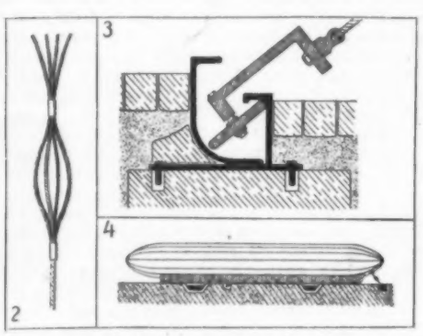


Fig. 2.—Quadruple Anchor Cable Distended by Steel Springs. Fig. 3.—Movable Anchor and Its Track. Fig. 4.—Airship at Anchor, Showing Protective Apron.

the longitudinal gangway should be about 20 inches above the surface of the grass-grown soil, and should be protected at its after end by leather bags filled with wool or shavings.

Thus anchored, the airship is little liable to injury from head or side winds. The injurious effect of puffs of wind which force themselves between the hull and the ground, and which contributed largely to the disaster that befell the "Zeppelin II." at Limburg, may be prevented by surrounding the lower part of the hull with an apron of sailcloth, with its lower edge stiffened by light metal rods and weighted with sandbags (Fig. 4).

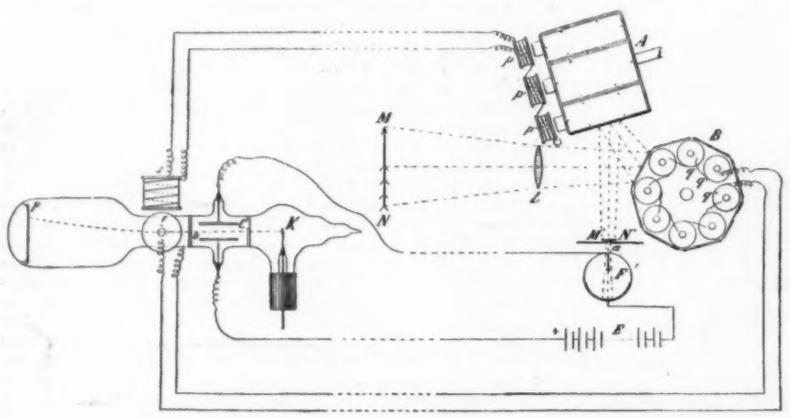
In order to prevent the rupture of anchor cables and other damages caused by sudden gusts of wind, it is advisable to employ a group of four cables, stretched over four curved steel springs wrapped with wire (Fig. 2). The elasticity of this contrivance will equalize the tension, diminish the effect of gusts and protect the airship and its connection with the cable from violent shocks.

The cost of constructing an anchorage of this sort would not be out of proportion to the importance of the purpose for which it is designed.—*Umschau.*

Prof. Rosing's "Electric Eye"—A New Apparatus for Television

SEVERAL methods of television, or seeing at a distance with the aid of wires and electric currents, have been announced in the course of the past decade, but none of these methods has come into practical use. The Russian journals now announce that Prof. Rosing, of St. Petersburg, has solved the problem of television. The following description of Rosing's method and apparatus is taken from an article contributed to *Cosmos* by Jacques Boyer, who derives his information from the *Bulletin* of the International Technical Society of St. Petersburg.

The "electric eye," as Prof. Rosing calls his apparatus, is illustrated in the accompanying diagram, of which the right-hand part represents the transmitting station, and the left-hand part the receiving station. In the diagram the stations are shown connected by six line wires, but the number of wires can be reduced to four. At the transmitting station two drums *A* and *B*, covered with plane mirrors, rotate on mutually perpendicular axes in such a manner that every point of the image *M' N'*, which is formed of the object *MN* by the lens *L* and the mirrors, falls successively upon a small aperture *a* in a diaphragm



PROF. ROSING'S "ELECTRIC EYE"; A NEW APPARATUS FOR TELEVISION.

Receiving station at the left—*K*, cathode; *P* fluorescent screen; *C*, condenser; *O*, diaphragm; *P*, electromagnets. Transmitting station at the right—*A B*, rotating drums carrying mirrors and magnets; *M N*, object; *L*, lens; *M' N'*, image; *A*, diaphragm; *F*, photo-electric globe; *E*, battery; *p p' p'' g g' g''* coils.

placed before a glass globe *F*. The interior of the hemisphere opposite the aperture *a* is lined with an alloy of potassium, sodium or rubidium, which is connected with the negative pole of the galvanic battery *E*. The negative charge which the alloy thus acquires is carried away by the negative ions which the alloy emits under the influence of the illumination which it receives from the aperture *a*. In this way a charge, varying in magnitude with the intensity of illumination or the brightness of the point of the image *M' N'*, opposite the aperture *a*, is transmitted to the condenser *C* at the receiving station, through the wires connected respectively with the alloy and with a positive electrode which occupies the center of the globe *F*.

The rotating drums *A* and *B*, which carry the mirrors, also carry magnets which as they pass the coils of wire *p p' p''* and *g g' g''*, generate alternating currents, which are transmitted to the receiving station where they energize the electromagnets *s* and *t*.

A pencil of cathode rays, emanating from the cathode of a Crookes tube *K*, traverses the common field of the two electromagnets, the axes of which are mutually perpendicular, and is thus subjected to deviations corresponding to the displacements of the image *M' N'* with respect to the aperture *a* at the transmitting station. The result is that the luminous point produced by the impact of the pencil of cathode rays upon the phosphorescent screen *p* moves in exact correspondence with the relative movement of the aperture *a* over the image *M' N'*.

Before the pencil of cathode rays enters the electromagnetic field it passes successively through a small orifice in a diaphragm (shown in the figure but not lettered), between the plates of the condenser *C*, and through a small orifice in a second diaphragm *o*. The relative positions of the two orifices and the cathode *K* are such that the rays do not fall on the second orifice *o* unless they are deviated by the electrostatic force exerted by the charged condenser, and that the fraction of the pencil that passes through the orifice *o* is proportional to the deviation, and therefore to the charge. Hence the intensity of the effective pencil and the brightness of the fluorescent spot are proportional to the charge of the condenser, and consequently to the brightness of the point of the image *M' N'* which momentarily illuminates the photo-electric alloy at the transmitting station.

In consequence of these electromagnetic and electrostatic actions exerted upon the cathode rays, every point of the image *M' N'* and the object *MN* is reproduced, with its proper relative brightness, on the fluorescent screen *p* at the receiving station. As the entire operation is repeated forty times per second, the fluorescent screen presents to the eye, in consequence of the persistence of retinal impressions, a motionless picture of the object *MN*. The fluorescent screen, the electromagnetic field, the diaphragms and the condenser are, of course, inclosed in the Crookes tube with the cathode *K*.

Aluminium Copper Alloys

THE British Association of Mechanical Engineers has a committee whose business is research concerning the properties of various alloys, which are now coming so rapidly into use. A recent report deals with alloys of aluminium and copper. Various experiments have shown that such alloys are erratic in behavior, especially under tests for "yield-point" and at high temperatures.

Copper alloyed with 7 per cent of aluminium was shown in some experiments to give disastrous results when employed for stay-bolts in locomotives. On the contrary, these alloys show good results in other ways. It has been shown that copper alloyed with from 1 to 10 per cent of aluminium becomes practically incorrodible in sea water. But this does not hold for tank water.

Cement-Protected Iron

THE use of cement to protect iron is not a new invention. At Brest the demolition of subaqueous constructions has brought to light iron bars which were thus covered, and which have remained in perfect condition for more than 100 years. At Rochelle a bridge erected in the fifteenth century was found to contain cement-protected iron, and the metal had not suffered from the effects of moisture.

TABLE OF CONTENTS

PAGE

I. AERONAUTICS.—Airship Anchorages.—By Major O. C. von Verschuer.—2 illustrations. 384

II. ARCHÆOLOGY.—Excavations at Susa.—By Our Paris Correspondent.—4 illustrations. 379

III. BIOLOGY.—Paris Oceanographic Institute.—By Our Paris Correspondent.—3 illustrations. 376

IV. CHRONOLOGY.—Fixing the Day of the Week of Previous Dates 371

V. ELECTRICITY.—Prof. Rosing's "Electric Eye"—A New Apparatus for Television.—1 illustration. 384

VI. GEOLOGY.—Stalactites.—By George H. Martin, M.A., F.C.S.—2 illustrations. 378

VII. MINING AND METALLURGY.—The Ultimate Limitation of Mineral Resources, and Its Significance to the Human Race. 375

VIII. MISCELLANEOUS.—The Alteration of Checks.—By William J. Kinsley.—13 illustrations. 372

IX. NAVAL ARCHITECTURE.—The "Olympic" and the "Titanic."—3 illustrations. 380

X. RAILROADS.—Steel Cars for Passenger Trains.—5 illustrations. 377

XI. PHYSICS.—Radiant Energy and Matter.—II. 370